

ROMANCE OF REALITY

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HOW ANIMALS WORK

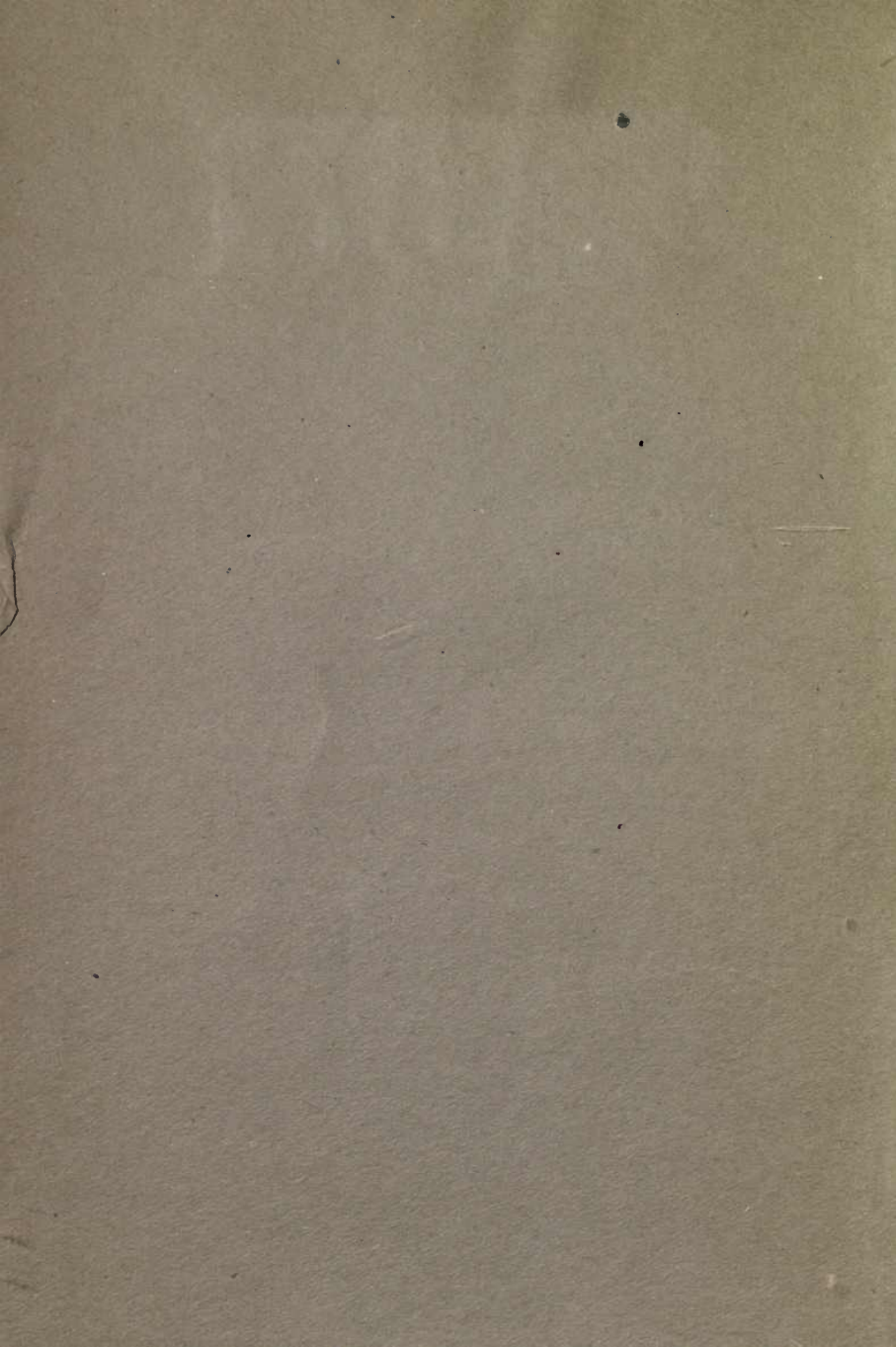
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"ROMANCE OF REALITY" SERIES

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HOW ANIMALS WORK

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HUMMING BIRDS.

"ROMANCE OF REALITY" SERIES

HOW ANIMALS WORK

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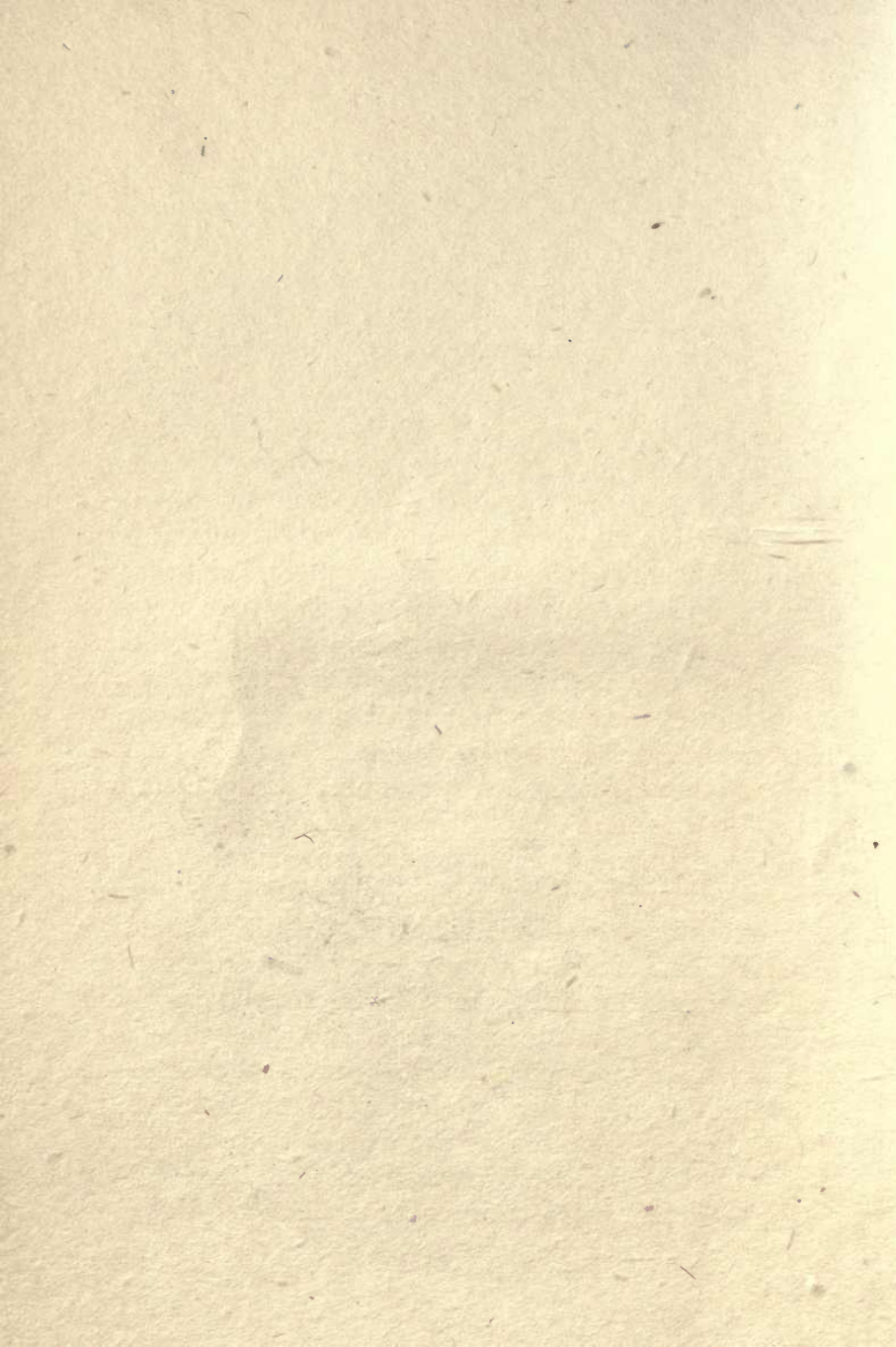
F. MARTIN DUNCAN

F.R.P.S., F.R.M.S.



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PREFACE.

IN the following pages I have tried to present to my readers a point of view of the great realm of animal life which has not received so much attention as some others, and which I venture to believe will be found of considerable interest—namely, animals as craftsmen: as the builders of imperishable monuments that will long outlast the most magnificent ever conceived and executed by man; and as the artificers of the daintiest, most fairy-like structures, so frail as to last but a few short hours. Some of the most beautiful of these works are accomplished by creatures quite low down in the scale of animal life—creatures destitute of brain or vision, little better than mere blobs of protoplasmic jelly, yet gifted with selective powers of a high degree in the gathering of their building materials, and of extraordinary skill in the construction of their exquisite homes. The animal craftsman has many lessons to teach, and at the same time presents many interesting problems that have yet to be satisfactorily answered; while careful observations of the methods of working, of the materials used, and the design of the completed structure, as peculiar to closely related species, will often reveal unsuspected steps in the history of their evolution.

Preface.

I have carefully avoided all technical terms as far as possible, and endeavoured to tell the story of some of the wonders of Animal Craftsmanship in plain and simple language ; for this little book is intended for the general reader, and not for the expert who has a store-house of technical literature at his disposal.

The very wealth of material from which to draw has been something of an embarrassment, where limited space has made it possible to give only a brief survey of certain forms, making it necessary to be somewhat drastic in the selection of examples. However, my guiding idea in their selection has been to place before the reader, as far as circumstances would permit, the most striking examples, and, at the same time, those which the reader can in a large number of cases see for himself, either during his rambles in the country, or by visiting any well-ordered natural history museum.

If these pages should serve to awaken a new interest in the marvels of Nature and the wonderful skill displayed by such varied forms of animal life, and perhaps stimulate the reader to seek himself for further examples, then my labours have not been in vain, and this volume will have justified its existence.

F. MARTIN DUNCAN.

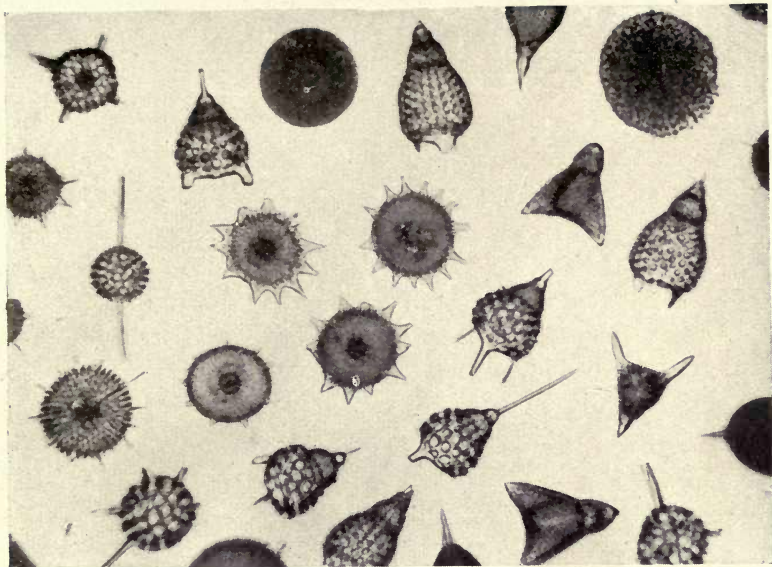
CONTENTS

CHAP.	PAGE
I. SOME MICROSCOPIC BUILDERS	9
II. ISLAND AND REEF BUILDERS	17
III. THE SHELL-BUILDERS	27
IV. SOME CURIOUS TUBE-BUILDERS	43
V. FISH AS NEST-BUILDERS	56
VI. WONDERS OF INSECT ARCHITECTURE: SOCIAL BUILDERS	65
VII. WONDERS OF INSECT ARCHITECTURE: SOLITARY BUILDERS	79
VIII. ANTS AND TERMITES	100
IX. WEAVERS AND SPINNERS	122
X. MINERS, DIGGERS, AND CARPENTERS	163
XI. SOME BIRD ARCHITECTS	189
XII. SOME FOREIGN BIRD ARCHITECTS	210
XIII. MAMMAL CRAFTSMEN	240
XIV. WORKERS IN PLANT TISSUES	250

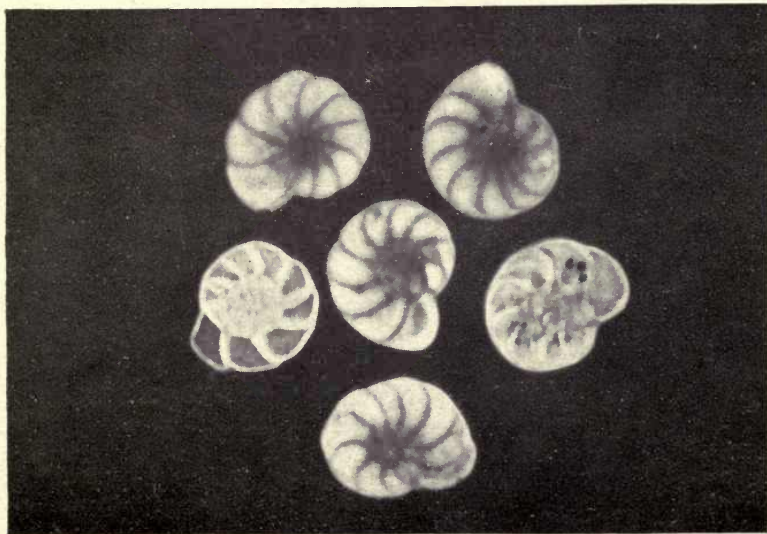
LIST OF PLATES

	HUMMING BIRDS (in Colour)			<i>Frontispiece</i>
PLATE				FACING PAGE
I.	THE WONDERFUL FLINTY STRUCTURES OF THE RADIO-			
	LARIA			8
	SOME OF THE MICROSCOPIC FORAMINIFERA			8
II.	FORAMINIFERA FROM THE FLOOR OF THE SEA			16
	A SECTION OF NUMMULITIC LIMESTONE			16
III.	THE DEVONSHIRE CUP CORAL			24
	TYPES OF SOLITARY "MUSHROOM" AND "CUP" CORALS			24
IV.	A SPRAY OF REEF CORAL			32
V.	A GROUP OF SHELLS			40
	A GROUP OF MARINE TUBE-BUILDING WORMS			40
VI.	THE ANT-LION LARVA			56
	STRANGE HOUSES			56
VII.	TYPES OF TREE-WASP NESTS			64
	THE MOLE CRICKET			64
VIII.	A QUEEN TERMITE OR WHITE ANT AND AN ORDINARY			
	WORKER TERMITE			104
	TWO VERY REMARKABLE PSYCHE CATERPILLAR GARMENTS			104
IX.	THE GARDEN SPIDER AND TARANTULA			128
X.	NESTS OF AN AUSTRALIAN TRAP-DOOR SPIDER			144
	A TRAP-DOOR SPIDER'S NEST, WITH "WAFFER" TYPE			
	OF DOOR			144
XI.	WORKERS IN SILK			156
XII.	THE NEST OF THE SONG THRUSH			192
XIII.	THE NEST OF THE LESSER REDPOLE			200
XIV.	THE REED WARBLER'S NEST			208
XV.	THE WONDERFUL NEST OF THE TAILOR BIRD			232
XVI.	THE NEST OF THE WEAVER BIRD			240

PLATE I.



THE WONDERFUL FLINTY STRUCTURES OF THE RADIOLARIA.
They are so minute that the microscope is required to make their beauty visible.



SOME OF THE MICROSCOPIC FORAMINIFERA.
They build the daintiest shells, resembling in shape the shell of the Great Nautilus.

HOW ANIMALS WORK.

CHAPTER I.

SOME MICROSCOPIC BUILDERS.

WE are accustomed to consider the construction of some finely proportioned building, or the production of a beautiful casket richly carved and moulded, essentially as work only to be attained by the creative brain and skilled fingers of the highly trained human craftsman. But to-day I would like to introduce you to quite another type of craftsman or builder—one who cannot definitely be said to possess any imaginative brains or deft fingers, and is destitute of sight and special tools, and yet is capable of constructing out of lime and silica the most exquisite caskets, spheres, spires, cornucopias, fretted, pierced, and bearing the most delicate sculpturings and tracery imaginable, yet all on so minute a scale as only to be made visible by the magnifying powers of the microscope. If we were to look at one of these brainless, sightless workers under the microscope after its tiny fairy mansion had been dissolved away, we should see that it appears to be just a minute blob of semi-transparent jelly, a speck of protoplasm, capable of certain streaming movements,

How Animals Work.

of sending out delicate threads or strands, mere elongations of the body mass, for the capture of food particles from the surrounding sea water in which it lives, and from which it extracts the carbonate of lime it uses as building material. Indeed, this little jelly-speck, denuded of its elaborate house, is almost exactly like the *Amœba*, the most primitive form of animal life; for, like that microscopic animal, it has no definite organs save the nucleus which is the vital part of all living cells, and can take in food particles at any part of its body, stream rather than creep along, and ultimately divide into two identical jelly-specks. But in place of the blunt, finger-like elongations which the *Amœba* pushes out as it moves along, our little builder puts forth delicate threads. I am sorry to say this interesting little creature has no popular name, it and its kin being known as the *Foraminifera*—a term first used by D'Orbigny to express the fact that the chambers of their microscopic mansions communicate by minute pores, and not by a tubular passage or siphon as in the chambers of the home of the *Nautilus*, to which animal he thought them to be related.

The exquisite shells of the *Foraminifera* are, for the most part, many-chambered, and often so strongly resemble those of the *Nautilus* and the *Spirula* that in days gone by the old naturalists, to whom their true structure was unknown, thought them to be related closely to the *Nautilus* and Cuttle-fish. Thanks to the high perfection of the modern microscope, their true nature has been revealed, showing not only the difference in the character of their bodies by which the shells are formed, but also the very different position of the body

Some Microscopic Builders.

in relation to the shell—anatomical details into which we need not enter here, it being sufficient to note that while the Nautilus inhabits but the last-formed chamber of its shell, each chamber of the Foram's shell is formed by, and continues to be occupied by, its own little segment or mass of protoplasm, the number of chambers increasing by a process of budding from the last-formed segment. The wonderful variety of shapes of these minute shells depends upon the plan by which the budding takes place, and two very distinct kinds of shell structure exist, while in one group of Foraminifera the true shell is entirely replaced by a sandy envelope, or "test," the particles of sand of which it is composed being held together by a natural cement exuded by the animal. The two kinds of shell are known respectively as porcellanous and hyaline or vitreous, while the "tests" formed of sand grains are called arenaceous. Under the microscope, when viewed by reflected light, a porcellanous shell bears a strong resemblance to the finest white porcelain; yet by transmitted light this opacity vanishes, and is replaced by a beautiful brown or amber colour sometimes tinged with red, while the surface is fretted and sculptured but never completely perforated. The shell of a vitreous or hyaline Foram, on the other hand, has an almost glassy transparency, and every chamber is beset more or less closely with complete perforations passing as small tubular openings direct from the outer to the inner surface. Through these pores the living Foram pushes forth fine strands of protoplasm into the surrounding water, and by their aid food particles are captured and absorbed; so that every segment of the body within the shell of a vitreous

How Animals Work.

Foram is engaged in the work of capturing food supplies, while in the porcellanous type it is only the last-formed segment that, issuing from the orifice of its chamber, spreads its protoplasmic strands abroad for the capture of food.

In the third group (Arenaceous Foraminifera), where the true shell is entirely replaced by a sandy envelope, or "test," when we come to consider the primitive form of life, a mere blob of protoplasmic jelly as it were, which selects and collects the particles of sand and builds them up into such graceful shapes, we cannot but be filled with admiration and wonder. Indeed, to quote the late Dr. Dallinger, who devoted many years to the study of microscopic forms of life, "there is nothing more wonderful in nature than the building up of these elaborate and symmetrical structures by mere 'jelly-specks,' presenting no trace whatever of the definite 'organization' which we are accustomed to regard as necessary to the manifestations of conscious life. Suppose a human mason to be put down by the side of a pile of stones of various shapes and sizes, and to be told to build a dome of these, smooth on both surfaces, without using more than the least possible quantity of a very tenacious but costly cement in holding the stones together. If he accomplished this well, he would receive credit for great intelligence and skill. Yet this is exactly what these little 'jelly-specks' do on a most minute scale, the 'tests' they construct, when highly magnified, bearing comparison with the most skilful masonry of man. From the same sandy bottom one species picks up the coarser quartz grains, unites them together with a ferruginous cement secreted

Some Microscopic Builders.

from its own substance, and thus constructs a flask-shaped 'test' having a short neck and a single large orifice. Another picks up the finer grains and puts them together with the same cement into perfectly spherical 'tests' of the most extraordinary finish, perforated with numerous small pores disposed at pretty regular intervals. Another selects the minutest sand grains and the terminal portions of sponge spicules, and works these up together—apparently with no cement at all, but by the mere 'laying' of the spicules—into perfect white spheres, like homœopathic globules, each having a single fissured orifice. And another, which makes a straight, many-chambered 'test,' the conical mouth of each chamber projecting into the cavity of the next, while forming the walls of its chambers of ordinary sand grains rather loosely held together, shapes the conical mouths of the successive chambers by firmly cementing to each other the quartz grains which border it. To give these actions the vague designation 'instinctive' does not in the least help us to account for them, since what we want to discover is the mechanism by which they are worked out ; and it is most difficult to conceive how so artificial a selection can be made by creatures so simple."

Of these Foraminifera whose shells are perforated by multitudes of minute tubules, the Globigerina, whose microscopic shell consists of an assemblage of nearly spherical chambers with coarsely perforated walls, is of particular interest, for its ancestors were abundant in the seas of a past geological epoch. To-day the Globigerina occurs in extraordinary abundance at great depths—from 1,260 to 3,000 fathoms—over wide areas of the

How Animals Work.

northern parts of the Atlantic Ocean, as much as 97 per cent. of the mud, or "ooze" as it is called, brought up from these depths being entirely composed of its minute shells. The living Globigerinæ frequent the surface waters of the sea, and their shells are bedecked with innumerable delicate spines which extend radially to a length equal to four or five times the diameter of the shell, giving them a most striking appearance; but on the death of the animal, the shell, in its descent to the great depth at which it at last reaches the floor of the ocean, loses its armature of delicate spines, so that only the tiny cluster of spheres remains. At these great depths, on the floor of the Atlantic to-day, new chalk is being formed in just the same way as it was at the bottom of the sea in past ages—by the constant accumulation of uncountable myriads of the remains of these Foraminifera; and in time to come these consolidated remains may in all probability rise above the surface of the sea to form dry land, in much the same manner as the chalk cliffs and the North and South Downs of England rose from out the sea in the long past. Even without the true knowledge of how they were formed, it is impossible to stand at the base of the towering, majestic white cliffs without feeling a thrill of admiration for their grandeur and beauty, at the absolute perfection of Nature's handiwork; and when we try to realize how they were gradually formed beneath the waters of the ocean, beneath the "stillness of the central sea," slowly, surely, perfectly through the long ages, until in the fullness of time they rose above the surface, monuments built from the accumulated remains of the infinitely minute, how truly glorious and awe-

Some Microscopic Builders.

inspiring do they become! Who can gaze upon their towering mass unmoved, or help recalling Tennyson's exquisite lines?—

“ There rolls the deep where grew the tree.

O earth, what changes hast thou seen !

There, where the long street roars, hath been

The stillness of the central sea.”

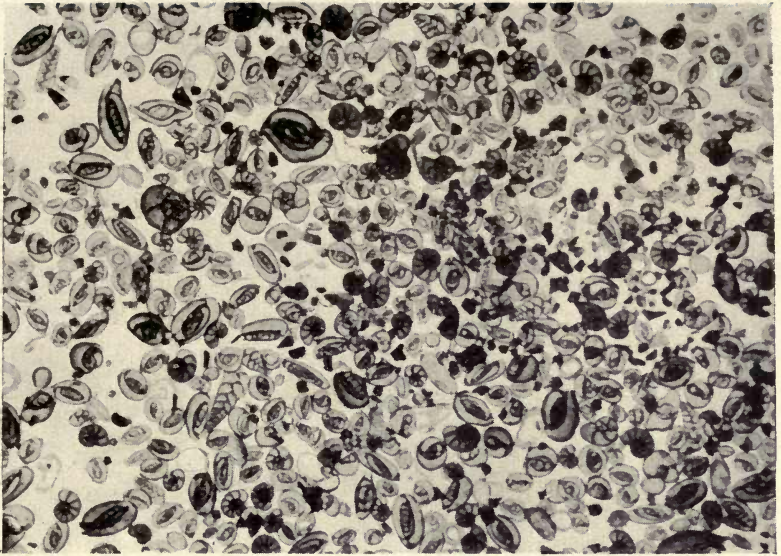
Living in the sea throughout untold ages, the Foraminifera have had, and probably still take, the largest share of any forms of animal life in building up and maintaining the solid calcareous portion of the earth's crust, by separating from its solution in sea water the carbonate of lime continually brought down by rivers from the land. Vast deposits of Foraminifera exist, and may be said to spread over thousands of square miles of the earth's surface. Nummulitic limestone, which is composed of disc-shaped Foraminifera called Nummulites, held together by a matrix formed of the finely crushed particles of their shells and of other small Foraminifera, is known to attain a thickness of several thousand feet. It has a wide geographical distribution, extending through Southern Europe, Greece, Asia Minor, Egypt, Persia, to China and Japan. The Pyrenees, the Carpathians, Apennines, Alps, and Himalayas, are mountain ranges into whose composition nummulitic limestone largely enters, while, as already stated, the large deposits of chalk are chiefly composed of the remains of Foraminifera. The vast accumulation of animal remains that this represents staggers the imagination, for it is very difficult to realize the long ages throughout which these remains steadily, unceasingly sank

How Animals Work.

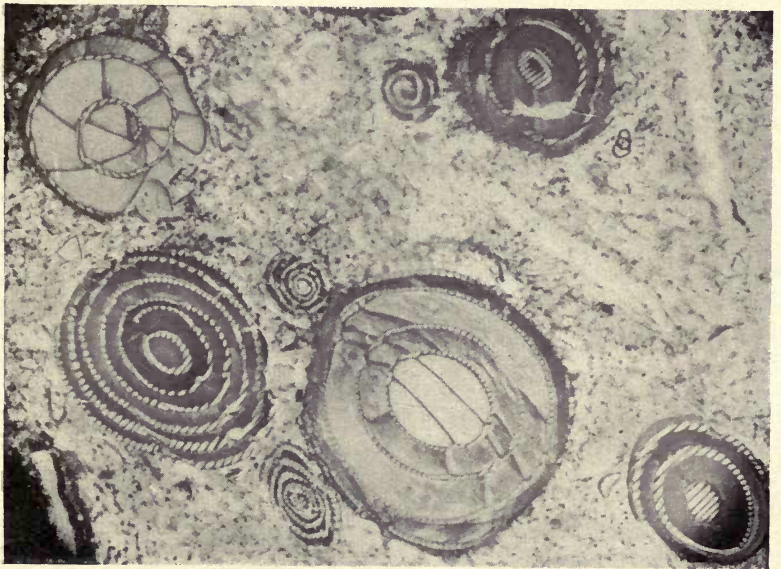
down through the depths of those seas of a past geological epoch. When we learn that a single cubic inch of Poorbandar limestone has been computed to contain more than a million Foraminifera, we realize the utter fruitlessness of attempting to give a numerical definition of these vast deposits.

Nor are the Foraminifera the only microscopic marine organisms which extract from the surrounding sea water the materials for the construction of exquisitely shaped and extremely minute homes. The somewhat closely allied Radiolaria make the most beautifully designed shells or "tests" of silica extracted from the sea, and their remains form an ooze at depths of from two thousand to three thousand fathoms. Like the Foraminifera, their history can be traced far back in the records of the past, their fossil shells being very plentiful in the rocks of Bermuda, Barbados, in Richmond, Virginia, and Sicily. The familiar Tripoli powder used for polishing consists largely of their remains. Their flinty "tests" are most varied and beautiful in shape, while the individual animal, again, is of the simplest character, destitute of any highly specialized limbs or organization, yet capable of extracting minute quantities of silica from the sea and working it up into the most graceful designs.

PLATE II.



FORAMINIFERA FROM THE FLOOR OF THE SEA.



A SECTION OF NUMMULITIC LIMESTONE.

Showing the fossil Forams of which it is almost entirely composed.

CHAPTER II.

ISLAND AND REEF BUILDERS.

PASSING from the comparatively simple one-celled animals we have been considering in the last chapter, the Corals next attract our attention as individually small, but extremely expert, builders and architects, producing the most graceful and varied structures, some frail and almost lacelike in appearance, others extraordinarily massive, yet covered with exquisite tracery.

The temperature of the sea round the shores of Great Britain to-day is not sufficiently high to support the life of the reef-building corals, although from the fossil remains preserved in various strata there is abundant evidence to prove that in a past epoch our shores were lapped by the waves of a tropical sea beneath whose surface coral life luxuriated. The reef-forming corals can only flourish in a warm sea, the temperature of which never falls below 68° Fahrenheit and may rise to 86°, and which is highly aerated, free from sediments, and containing an abundance of minute living organisms which constitute the food of the coral animals, or polyps. Also the reef-builders do not appear to be able to live at such great depths as their simple solitary relations, probably because the temperature of

How Animals Work.

the sea diminishes rapidly with increasing depth, so that the 86° to 70° Fahrenheit necessary for the luxuriant growth of the reef-building forms is not maintained much beyond a depth of some twenty fathoms, the greatest depth from which living specimens of reef-building corals have been dredged up being fifty fathoms.

Although we cannot boast of any living coral reefs off the coasts of Great Britain to-day, still the visitor to the seaside, and more particularly to the south coast of Devon and Cornwall, may have an opportunity of seeing a little living solitary coral, called the Devonshire Coral (*Caryophyllia Smithii*), growing attached to rocks in deep pools at extreme low tide. This little cup coral rarely exceeds an inch in diameter, and when the soft parts of the animal are fully expanded the little creature resembles very closely a small sea-anemone. On top of the body there are a series of semi-transparent tentacles, paler of hue than the rest of the body, and terminating in knoblike expansions. There is a central disc within the circle of tentacles, in the midst of which is the little elongated slitlike mouth. A tissue similar to the outside of the tentacles and disc covers the body, while the disc is marked with lines which appear to radiate from the mouth, and which on being touched contract slightly, so that a hard structure is felt beneath them, made up of a series of thin, vertically arranged plates with their edges upwards. The general appearance of this interesting little coral is clearly shown in the photograph (*a*, Plate III.). Minute organisms floating in the water are brought into contact with the top of the coral and carried down into the mouth, and it is partly from the calcareous parts of such prey, partly from the salts

Island and Reef Builders.

of lime held in solution by the sea water, that the hard parts of the coral are formed.

This little Devonshire cup coral, so like a small anemone in life, discloses, after its death and the decay of its fleshy parts, a skeleton of singular beauty, composed of carbonate of lime, and originally deposited beneath the tissues of the living animal. This cup-shaped coral is, to all intents and purposes, identical with the reef-forming corals, but leads a solitary life, while the reef-builders form colonies by budding, the buds not becoming detached. As a result of long-continued budding, extending layer over layer, the large solid masses which go to form the coral reefs are gradually built up. Of the rate of growth of these immense masses of coral the marine biologist has yet much to learn ; but some idea of the comparatively rapid growth made under favourable conditions may be gathered from the already ascertained facts, which show that one coral animal, or polyp, one millimetre in diameter has been known to bud out and form 693 grammes of coral in thirty-six months. We know but little concerning the duration of the life of these stony corals, beyond the fact that the power of increase by budding, or asexual reproduction as it is called, is not unlimited, and that these colonies, like individuals, have their allotted span of life, attaining to a maximum rate of increase and then growing old, senile, and at last die a natural death. So far as our present knowledge goes, the duration of life in some of the solitary corals has been estimated at about twenty-four years, while some of the reef-building colonial forms are thought to live from twenty-two to twenty-eight years.

How Animals Work.

Looking at the little Devonshire Coral growing in its deep rock pool, a frail, gelatinous creature, it is difficult to realize that these anemone-like animals, individually comparatively insignificant in size, by the accumulations of their living skeletons form the reefs and coral islands of the tropical seas ; that masses of rock extending many leagues, like the Great Barrier Reef of Australia, have been built up by them beneath the surface of the waves. To quote Montgomery's delightful lines,—

“ Millions of millions thus, from age to age,
With simplest skill and toil unwearable,
No moment and no movement unimproved,
Laid line on line—on terrace terrace spread,
To swell the heightening, brightening gradual mound,
By marvellous structure climbing toward the day.
Each wrought alone, yet all together wrought
Unconscious, not unworthy instruments,
By which a hand invisible was rearing
A new creation in the secret deep.

.

I saw the living pile ascend,
The mausoleum of its architects,
Still dying upwards as their labours closed :
Slime the material, but the slime was turned
To adamant by their petrific touch :
Frail were their frames, ephemeral their lives,
Their masonry imperishable.”

All corals are very similar in the anatomy of their fleshy parts ; yet how variable in shape, size, and detail of structure is the skeleton they form ! Some, like the so-called “Mushroom” corals, remain solitary individuals ; others, again, by a process of budding may

Island and Reef Builders.

grow out in the most graceful branches, fans, and arborescent forms, or become compact, rounded masses like the "Brain" corals, or grow into large, solid masses of many tons weight. No matter what the final size and shape of the colony, it had its origin in a single individual. First a little projection appeared on the side of the parent cup, and soon a few tentacles were formed, until by its outward and upward growth the little bud became like its parent in appearance. Other buds then arose, and all grew upwards in a bushlike form, fresh successions of buds constantly appearing. As this growth progresses, either the bushy shape remains, or else structures composed of layers of hard material, arranged in cellular compartments or cross-bars so as to give both strength and lightness, are formed between the buds, connecting the whole into a compact and solid mass. While these reef-building corals are comparatively shallow-water forms, and are restricted to the warm, sunlit waters of the Tropics, the solitary corals have a far wider distribution, and some have been dredged up from very great depths. Besides the process of budding just described, corals also have a true sexual method of propagation. The oval-shaped young escape from the mouth of the parent, and swimming by means of delicate threads, or cilia, soon fix themselves to a base, and become like the parent in appearance.

The work of the reef-building corals comes under three headings: (1) Shore reefs, which fringe the shores of continents and islands; (2) barrier or encircling reefs, which rise from deep water at a greater distance than the fringing reefs from land, so that there is a

How Animals Work.

channel-way navigable by ships between the reef and the mainland, the reef either encircling an island or stretching as a natural barrier along the coast, like the wonderful reef which fronts the north-east coast of Australia with a length of nearly a thousand miles ; and (3) atolls, or lagoon islands, which are low reefs, rising but a few feet above the highest tide level, and enclosing a lagoon.

An atoll presents a most remarkable appearance to the voyager, as seen from the deck of the approaching vessel. Rising out of the deep blue sea is seen a low, more or less circular belt of land, dotted with feathery-crowned cocoanut palms. A white line of breakers fringes the shore, thundering upon it and sending up great fountains of spray, while within the encircling reef the waters of the lagoon shine with unruffled surface like a burnished mirror. One would imagine that the hardest rock must yield to the perpetual onslaught of the mighty waves that day and night break with cataract force against the reef, and that in a few years all trace of land would disappear beneath the surface of the sea. " Yet," as Dr. Hartwig writes, " the insignificant coral islets stand and are victorious ; for here another power, antagonistic to the former, takes part in the contest. The organic forces separate the atoms of carbonate of lime one by one from the foaming breakers, and unite them in a symmetrical structure. Let the hurricane tear up its thousand huge fragments ; yet what will this tell against the accumulated labours of myriads of architects at work night and day, month after month ? Thus do we see the soft and gelatinous body of a polyp, through the

Island and Reef Builders.

agency of vital laws, conquering the great mechanical power of the waves of an ocean, which neither the art of man nor the inanimate works of Nature could successfully resist."

The outer side of the atoll usually sinks to a depth of some two hundred to three hundred fathoms, shelving abruptly at an angle of forty-five degrees or more, and it is on this outer edge only that the solid wall increases. Here the coral animals thrive in the midst of the surf occasioned by the breakers—an ever-changing and highly aerated body of water washing over their surface, bringing to them an abundance of oxygen and food. During violent storms huge masses are torn off by the force of the waves, and driven on shore towards the lagoon; but scars left by the detachment of these masses serve as places of attachment for the young of the neighbouring corals, the successive generations of which, by their rapid growth, not only repair the damage caused by the storm, but increase the outer area of the reef.

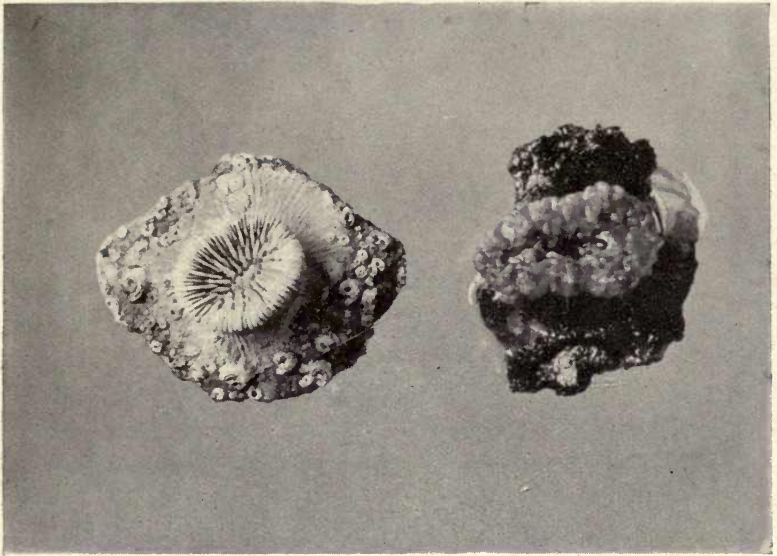
While these reef-building corals cannot exist in a vigorous state of growth at a greater depth than twenty to thirty fathoms, owing to their need of light, warmth, and highly oxygenated water, their tissues are so delicate that a brief exposure to the air and the sun's rays kills them. Thus it is only by constant immersion in clear, warm, highly aerated sea water, absolutely devoid of muddy sediment, that they can thrive. As the living reef-building corals cannot flourish beyond a depth of thirty fathoms, it seems obvious that the atolls and barrier reefs are resting upon some substratum which could not possibly have been formed by reef-building corals at the same relative position it has now. What,

How Animals Work.

then, is the substratum, and how was it formed? If composed of a coral rock, then it is clear that it must have been formed at a time when it was nearer to the surface of the sea than it is now, and that it must later on have subsided to greater depths. If, however, this substratum is a primitive rock, then it would appear that in such regions as the Indian and South Pacific Oceans, where archipelagoes and atolls extend for hundreds of miles, there must exist submerged chains of mountain ranges whose peaks reach to a uniform level beneath the surface of the sea. This is highly improbable, for, as Charles Darwin states in his *Coral Reefs*, "we cannot believe that a broad mountain summit lies buried at a depth of a few fathoms beneath every atoll, and nevertheless that throughout the immense areas above named not one point of rock projects above the level of the sea. For we may judge of mountains beneath the sea by those on land, and where can we find a single chain, much less several such chains many hundred miles in length, and of considerable breadth, with broad summits attaining the same height from within one hundred and twenty to one hundred and eighty feet?"

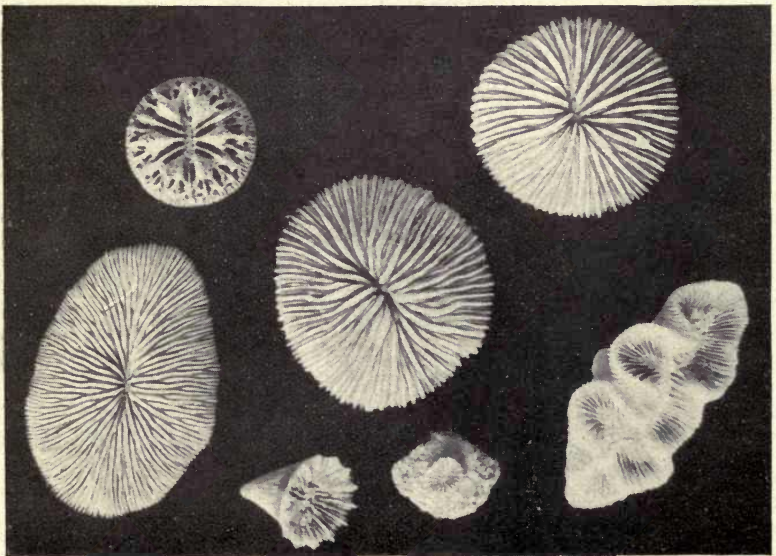
To account for this, Darwin worked out his famous subsidence theory, according to which the regions where atolls now occur were once dry land, or an archipelago of volcanic islands surrounded by fringing coral reefs. We have the most convincing proof in almost all parts of the world that land has disappeared beneath the surface of the sea, only to reappear again at a later epoch in the earth's history. Thus Darwin, as in all his work, was building his theory upon a solid foundation of ascertained fact. In the regions, therefore, where

PLATE III.



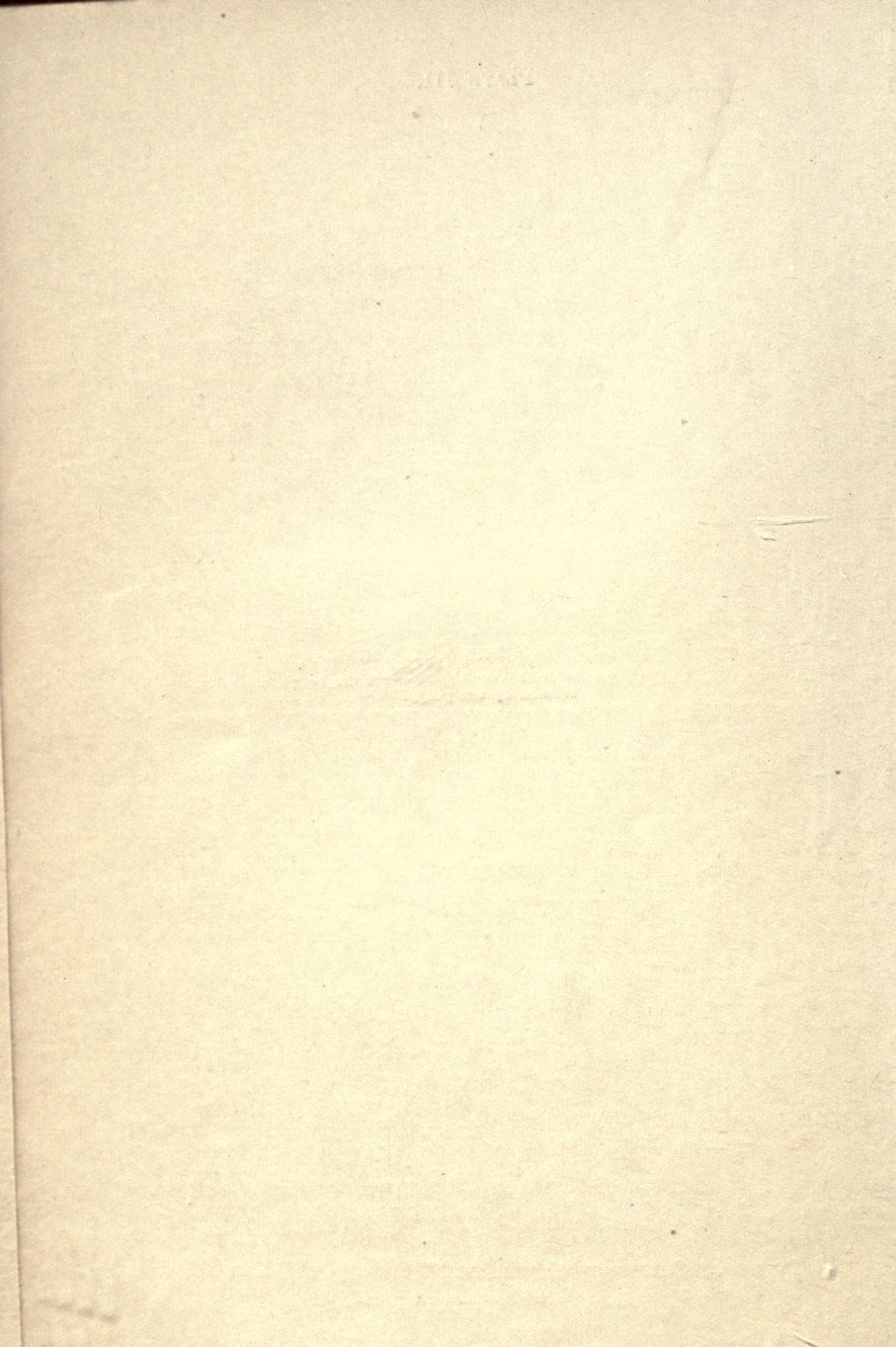
THE DEVONSHIRE CUP CORAL.

On the right is the expanded polyp, and on the left the beautiful skeleton formed by the polyp.



TYPES OF SOLITARY "MUSHROOM" AND "CUP" CORALS.

Each the work of a single polyp.



Island and Reef Builders.

the atolls exist to-day, the land, according to his theory, gradually subsided and its area diminished; but the area enclosed by the coral reefs did not diminish in a corresponding degree, and the young corals, growing on the debris of the older ones as they sank, continued the growth of the reef in a direction nearly vertical to the sea bottom. In this way the fringing reefs gradually became barrier reefs, and were separated from the mainland by a lagoon of considerable depth. Finally, when the mountain peaks disappeared beneath the waves, a ring-shaped reef or atoll was all that remained to mark the position of the former land.

The fundamental assumption of Darwin's subsidence theory is that the substratum of the coral reefs and islands is coral-formed limestone. Borings recently made on the island of Funafuti, in the Pacific Ocean, to test the truth of this assumption, were successfully carried out to a depth of 1,114 feet. The result absolutely proved and confirmed the justice of Darwin's assumption as to the nature of the substratum, for in the cores from various depths down to the very lowest obtained by the boring, the fossilized skeletons of the common genera of recent corals, and very few or no representatives of genera of corals now extinct, were discovered, giving the fullest possible support to the subsidence theory as applied to this particular island. As I have stated elsewhere,* that Darwin's "theory of gradual subsidence may not be applicable in a few cases is quite possible. Other natural causes, such as the abundant deposition of the remains of calcareous organisms, may have been, under favourable condi-

* *Cassell's Natural History.*

How Animals Work.

tions, sufficient to raise the summits of submerged mountains to a level where the reef-forming corals can commence to flourish. But these isolated cases all require far more careful and systematic investigation than they have yet received, and though, under certain favourable conditions, atolls and reefs may thus be formed without the subsidence of land, their presence in no way upsets Darwin's theory as applied to the innumerable examples of the various reef formations which stud the Indian, Atlantic, and Pacific Oceans."

No matter in what situation the skeletons of these reef-building corals may be found—whether at a height of 7,000 feet above the level of the sea, or at a depth of 300 feet beneath its surface—they must have grown and formed their beautiful and wondrous skeletons within about twenty fathoms of the surface of the sea. On the summit of the lofty mountains of Tahiti, at 5,000 and 7,000 feet above the sea level, a regular stratum of semi-fossilized coral has been found ; while it has also been dredged up from 200 to 300 fathoms, to which depth it must have been dragged down by a gradual subsidence of the foundation upon which the living, reef-building corals once flourished. It is a marvellous story of earth movement, written by Nature upon the face of the earth in characters that all may read, and as we ponder those slow but certain upward and downward movements of the land, Tennyson's lines stand out in their crystal truth :—

" The hills are shadows, and they flow
From form to form, and nothing stands ;
They melt like mist ; the solid lands,
Like clouds they shape themselves and go."

CHAPTER III.

THE SHELL-BUILDERS.

" See what a lovely shell,
Small and fine as a pearl !

Frail, but of force to withstand,
Year upon year, the shock
Of cataract seas that snap
The three-decker's oaken spine
Athwart the ledges of rock."

TENNYSON.

I THINK that every visitor to the seaside must, at one time or another, have been attracted by some daintily tinted shell left stranded by a retreating wave, all glistening and iridescent with the salt spray, and reflecting endless rainbow tints. Captivating by its pretty colours, the shell was probably picked up, and for a time kept as a memento of a pleasant summer holiday by the sea. Now I would ask you to come with me for a ramble along the shore in search of fresh specimens ; or let me draw your attention to a few from my cabinet, that we may consider them in quite a different aspect, not merely as pretty objects, part and parcel of the flotsam and jetsam of the shore, but each as a house beautiful—a house perfect in its design to

How Animals Work.

meet the requirements of its original owner and builder : for every shell on the seashore and in the rock pools has been formed, tinted, and moulded into shape by its original inhabitant.

Considered from this point of view, I think you will agree with me, every shell has quite a new and increased interest. It is no longer merely a pretty object, but a wonderful piece of constructional work, beautiful in its colour and design. One at once feels anxious to know more about it, and to try to find out something of the creature that formed and dwelt in it.

“ Did he stand at the diamond door
Of his house in a rainbow frill ?
Did he push, when he was uncurled,
A golden foot or a fairy horn
Thro’ his dim water-world ? ”

The creatures that form these exquisite dwellings all belong to that great division of the animal kingdom called the *Mollusca*, and really they are a very remarkable assemblage, varying to an extraordinary degree in shape, size, colour, and habits of life. Some are only to be found on land, others are restricted to the ponds, lakes, and rivers, while a very large proportion are dwellers in old Neptune’s kingdom. Nor do they all form a portable house or shelter, for in some species the shell may be hidden from view, may be of a very rudimentary character, or entirely absent. Some, again, not only construct a portable dwelling, but are expert masons, boring into the rocks, and making regular burrows wherein to dwell ; or, as in the case of the Lima, shortly to be described, construct a receptacle composed of fragments of gravel and coral.

The Shell-builders.

What of the material out of which the animal constructs its shell, and the apparatus used in the work? Carbonate of lime is the essential building material, and is obtained from the seaweeds and other vegetable matter which the animal eats ; while, should it be a carnivorous Mollusc, by devouring others that are plant eaters it obtains its supply in a second-hand manner. In the work of constructing the shell the animal has no elaborate apparatus at its command, the work being performed by the external membranous layer that invests the body—the mantle, as it is called, albeit a delicate and remarkable organ. The thickened margin of the mantle is glandular, and contains in its substance patches of various colours. It is this thickened margin which produces the material for the increase in size of the shell, while the colour patches correspond both in their tint and relative position with the colours that decorate the exterior of the shell. When the little shell-builder is engaged in increasing the dimensions of its portable dwelling, the margin of its mantle is protruded, and firmly adheres to the margin of the shell. In this position the mantle secretes the calcareous matter, depositing it in a soft condition upon the extreme edge of the shell, where this secretion soon hardens into a solid shelly layer. This process is repeated again and again at regular intervals, each succeeding layer further enlarging the diameter of the shell.

The quantity of this calcareous material secreted by the edge of the mantle appears to be much more copious at certain periods than at others, and it is at such times of abundant supply of material that ridges, broad plates, or spines of different length are formed by the mantle

How Animals Work.

extending beyond its usual position at the circumference of the shell. In this way the external surface of the shell is exclusively formed of layers deposited in succession by the margin of the mantle. The coloured spots in the tissue of the mantle are pigment glands, capable of manufacturing the necessary colours for the external ornamentation of the shell, and the pigment furnished by these glands becomes mixed up with the calcareous matter at the time of its deposition. According to the amount of pigment produced, and whether a continuous supply is kept up during the whole period that fresh material is being deposited in the process of enlargement of the shell, or the supply of pigment is only forthcoming at intervals, so the shape and size of the bands and patches of colour on the surface of the shell will vary.

The margin of the mantle, therefore, is the sole mechanism for enlarging the circumference of the shell and its coloration ; but the growth in *thickness* of the shell is attained by the secretion of a kind of calcareous varnish produced by the external surface of the mantle generally. This secretion is deposited layer by layer over the whole of the previously existing shell, and in this way the weight and solidity of the shell are progressively built up. Moreover, this thickening material differs from that produced by the margin of the mantle, inasmuch as it is not pigmented, but is of a beautiful, lustrous white hue, and forms the well-known iridescent material called nacre, or mother-of-pearl.

The edge of the mantle is very often fringed with small, delicate, and sensitive tentacles, and in some of the Clams and Scallops (*Pecten*) numerous brightly

The Shell-builders.

coloured eyes may be seen amongst them, presenting a most beautiful appearance. If a healthy Scallop is placed in a glass jar filled with fresh sea water, its movements can be watched, and a good view of its lovely mantle obtained. The shells will soon begin to open, and then the fleshy mantle can be seen to occupy the interval, like a narrow veil extending perpendicularly from each shell. "The edge of each of these veils will now be seen, if you examine it with a pocket lens, to be fringed with long white threads, which are the tentacles, or organs of touch; and amongst them lie scattered a number of minute points, having the most brilliant lustre, and bearing a close resemblance to tiny gems. Indeed, the mantle has been aptly compared to one of those pincushions which are frequently made between pairs of these very shells, the eyes representing a double row of diamond-headed pins set round the middle." *

Next to the mantle, the foot is the most remarkable and useful organ possessed by the Mollusc, and is employed in various ways—for digging holes in the soft sand, to drill a hole in the hard rock, or as a sort of sand-plough, shovelling the sand away on either side to form a trench, along which the Mollusc moves. In many instances the foot is so large that when it is pushed out it is considerably bigger than the shell from which it has been protruded. The whole body of the animal often swells out to such an extent, as it issues from the shell, that it reminds one of the old story of the Eastern Genii who came out of a bottle. When fully distended it looks as if it were impossible for the creature ever to pack itself away again inside its house. Yet, if alarmed,

* P. H. Gosse.

How Animals Work.

it seems to shrivel up, and with extraordinary rapidity disappears within its protecting shell.

The shell-builders may be broadly divided under two headings: namely, those which construct a single shell—univalves, as they are called; and those which construct double or twin shells—called bivalves. While the bivalve Mollusc can close its twin shells, and thus be cut off from intercourse with the outer world, the univalve has a single permanent opening to its shell, through which the head and foot can be pushed forth when the Mollusc wishes to go for a stroll. Most univalves, however, have a kind of door that fits quite tightly into the opening in the shell when the animal retires within, and this is called the “operculum.” It is a thin, shelly, or horny plate, usually carried fixed to the upper surface of the foot of the Mollusc, so that the animal may be said to open or close the front door of its house by the single expedient of pushing forth or drawing back its foot. The operculums of many Molluscs are very pretty things, delicately coloured, and marked with lines running round and round in the form of a spiral.

It is among the univalves that many of the most beautifully shaped and coloured forms are to be found, while the inhabitants of univalve shells are nearly always curious or interesting in one way or another. The “Screw-shells” to be found on rocky coasts are made up of a number of rings or coils, and perhaps represent the most perfect development of a spire-shaped shell. The largest coil or “whorl” forms the base of the shell, and each succeeding whorl is smaller until the apex of the spire is reached. This spiral form is very

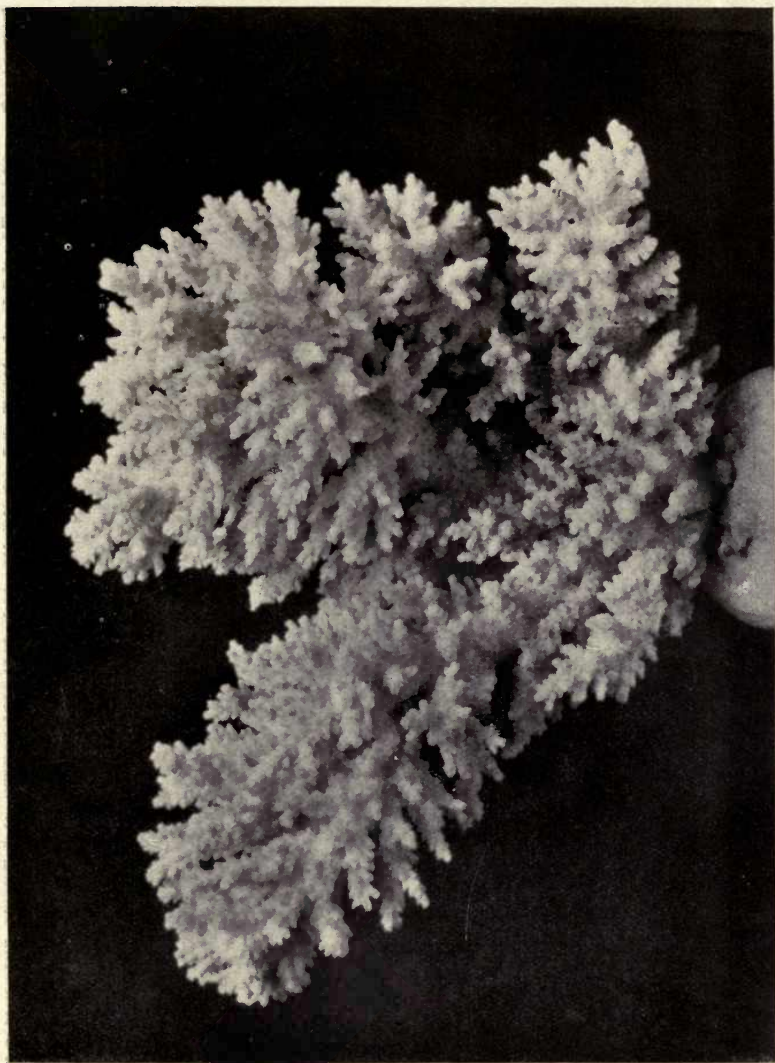
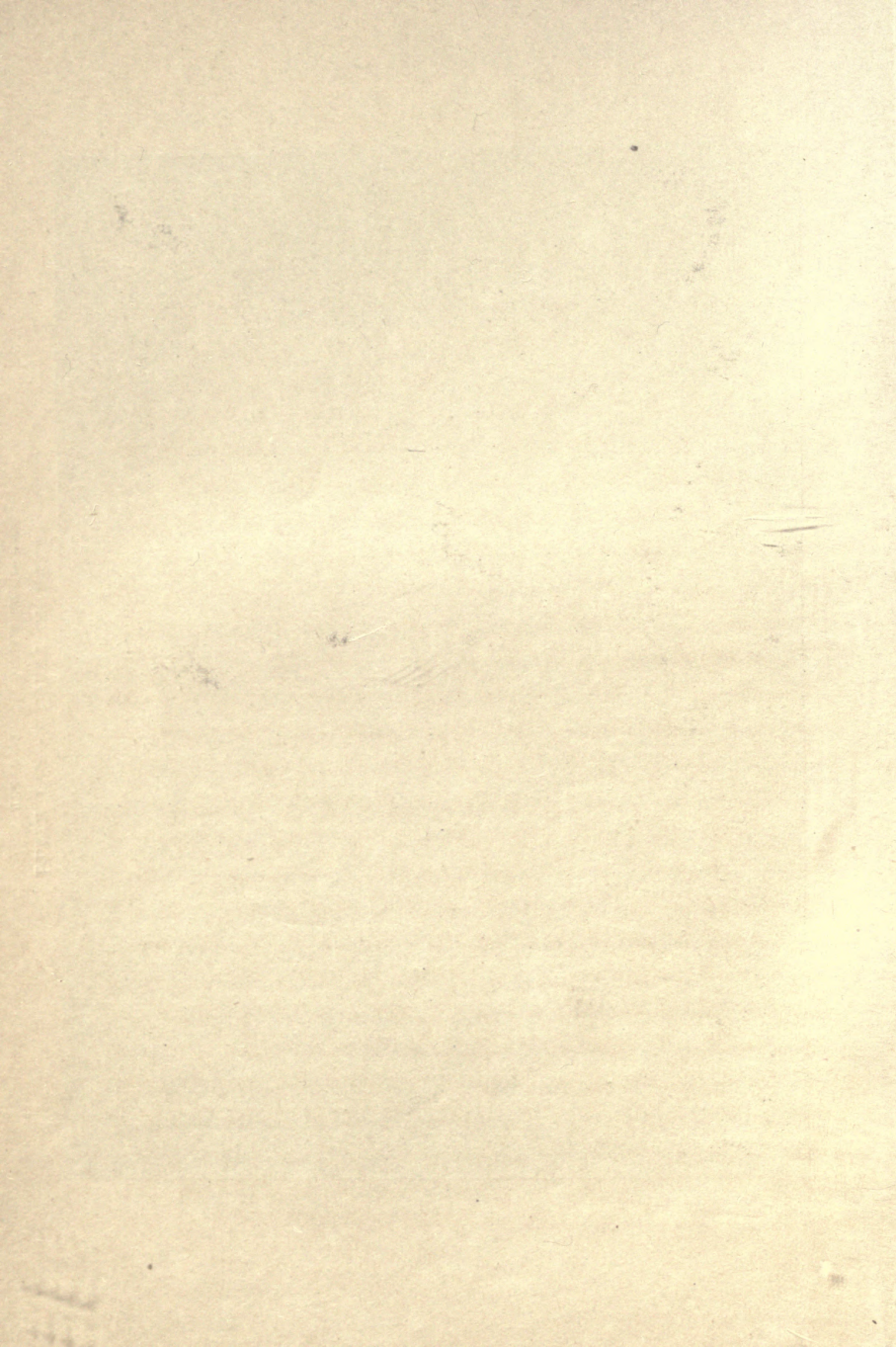


PLATE IV.—A SPRAY OF REEF CORAL.

The work of countless tiny polyps.



The Shell-builders.

typical of univalve shells, though sometimes the whorls are not so plainly discernible.

The Ladder-shells, or Wentletraps, are beautiful examples of spire-shaped shells, thick and smooth, and made up of many distinct whorls, each whorl being crossed with several raised ribs running from the top to the bottom of the shell. The little builder of such a graceful house lives in deep water, where the sea floor is rather a mixture of sand and mud, and when disturbed is said to squirt out a jet of purple fluid. One of these Wentletraps, living in Tropic seas, is a beautiful pale yellow, with ribs of pure white, and for many years commanded a high price amongst collectors. In 1753 four sold for £75, 12s., while one, which was sold a little later, was valued at £27. Nowadays specimens are more numerous, and can be purchased for a few shillings.

In the "Pelican's Foot" shell we find the little Mollusc that forms it departing from the perfect spiral shape; for although the upper part consists of a series of diminishing whorls, the lip of the shell is very large, flattened on one side, and spreads out like the webbed foot of an aquatic bird—from which the shell has gained its popular name. In colour this strangely shaped shell is a pale creamy yellow, sometimes nearly white, daintily clouded with tender purplish tints, with here and there a splash of chestnut-brown; while the whorls are sculptured with bosses and indentations.

The Trochus, the Mollusc which forms the so-called "Top-shell," is a dainty little creature with a well-shaped head bearing a pair of slender horns or tentacles, and a pair of eyes mounted on foot-stalks. On each side of the head is a large lappet, part of the

How Animals Work.

outer edges of the mantle, which broadens out like a wing, and is bordered with a delicate fringe of the finest hair, or cilia. As the little *Trochus* moves slowly along through the water, the rippling, wave-like movements of the fringe of cilia cause a wonderful play of iridescent colours round the head of the Mollusc, making it look as if dressed in "a rainbow frill." In fact, one cannot help feeling that it is the original of Tennyson's lines. The shell has a nearly flat broad base, and tapers abruptly, so that the general shape is something like a squat peg-top; but both shape and colour vary a good deal in different species, some being much taller than others and quite smooth, covered with little knobs, or with a tracery of ridged lines running round and round from the base of the shell to the apex.

A living Ormer, or Ear-shell, does not present at all an interesting or striking appearance, and one would never imagine that beneath that rough, grayish-brown exterior lay hidden the most gorgeous tints, vivid as a tropical sunset, softly opalescent—the whole gamut of an artist's palette. When, however, the shell is empty and its tenant dead, it is seen to be lined with the most beautiful mother-of-pearl, while the removal of the outer rough layer and subsequent polishing of the upper surface will reveal fresh wonders of coloration.

The Cowries of the Tropic seas offer a contrast in shell structure, for, instead of the dull, rough exterior of the Ormer, their surfaces are always more or less brightly coloured and highly polished, the wonderful smooth glistening surface being produced by the mantle, which folds back over the outer surface of the shell

The Shell-builders.

when the animal is alive. The little Cowrie which is found on our English shores, the *Cypræa Europæa*, though small of size and minus the vivid colours of its tropical relations, is nevertheless a dainty, interesting little shell. It is marked all over with fine transverse ridges and alternate furrows, the ridges being of pure white, the furrows purplish or flesh colour, while larger specimens often display three dark-brown spots.

To quote from Gosse's delightful description :—
“ Probably few are aware how very elegant a creature it is when tenanted by its living inhabitant and crawling at ease in clear water. The foot, on which it glides with a slow but smooth motion over the surface of the rock on which it habitually dwells, is a broad expansion spreading out to twice the superficies of the base of the shell. Above this is the fleshy mantle, which is so turned up as to closely invest the shell, conforming to its shape, and even fitting into the grooves between the ridges. This mantle can be protruded, at the will of the animal, so far that the two sides meet along the top of the shell and completely cover it, or can be completely retracted within the wrinkled lips beneath ; and it is capable of all gradations of extension between these limits. From the front of the shell protrudes the head, armed with two straight and lengthened tentacles, answering in function and appearance to the upper part of the horns of the snail, except that the little black points which constitute the visual organs are not in this case placed at the tips, but on a little prominence on the outside of the base of each tentacle. Above and between these, which diverge at a considerable angle, projects the proboscis, a rather thick, fleshy tube, formed

How Animals Work.

by a flat lamina, with its edges bent round so as to meet along the under side. The interior of this proboscis is lined with delicate cilia, by whose constant vibrations a current of water is drawn into the tube, and poured over the surface of the gills for the purpose of respiration. Let us now look at the vivid hues of these organs. The foot, which expands to so great a length and breadth behind the shell, is of a buff or pale orange ground colour, delicately striated with longitudinal undulating veins of yellowish white. The mantle, which embraces the shell, is of a pellucid olive, thickly mottled and spotted with black, and studded with glands protruding through its substance of light yellow, and it is edged with a narrow border of red. The proboscis is vermilion-red, varying in brilliancy in different individuals. The tentacula are of a paler tint, of the same colour, speckled with yellow. Such, then, is the beauty of the animal which inhabits this familiar and plain little shell—a beauty of which those who know it only in cabinets can hardly form an idea; which, as one gazes on it placidly gliding along, one cannot help an emotion of surprise that such an amplitude of organs can be folded within the narrow compass of the shell, and protruded through so contracted an aperture.”

The univalves which build the largest and most massive shells are the Helmet (*Cassis*) and the Conch (*Strombus*) shells, which frequently attain a length of ten or twelve inches or more, and a weight of over four pounds. Large numbers of them are imported into Europe annually, and are used in the production of cameos, an art in which the Italians excel.

Now let us consider a few of those Molluscs that

The Shell-builders.

form a double shell in which to dwell. Amongst them not only are there many which produce most exquisitely coloured and gracefully shaped shells, but some which go further than the secretion of a shelly protection, and which are weavers, masons, and miners.

Largest of all the bivalve Molluscs is the Giant Clam, which inhabits the Indian Ocean. The great shell often weighs upwards of 500 lbs., while the animal which lives within and formed these immense valves attains a weight of 20 lbs. They are frequently to be seen in the quiet lagoons of coral islands, or atolls, with their great valves partly opened; and Darwin, describing his visit to Keeling Atoll, says: "We stayed a long time in the lagoon, examining the fields of coral and the gigantic Clam shells, into which if a man were to put his hand he would not as long as the animal lived be able to withdraw it." The exterior of the Clam shell is deeply grooved and moulded, presenting a very handsome appearance.

Another interesting bivalve inhabitant of the coral reefs is the *Spondylus* or Thorny Oyster, which, although never reaching the gigantic proportions of the Clam, is a fairly large and handsome Mollusc. The exterior of both upper and lower valves is covered with spines, which on the centre and towards the apex are more or less sharply pointed and slightly curved like thorns, while as they approach the outer edges of the valves they increase in length and broaden out in foliaceous expansions. An interesting peculiarity of the *Spondylus* is that with advancing age the shell does not increase in size, but becomes thicker in its interior by the addition of inner layers of shell, which are dis-

How Animals Work.

inct from the outer and from each other. This reduction of the inner space appears to be effected in order to counteract the continued increment of the shell, by the deposits of new material along its margin from the border of the mantle, at a greater rate than is required for the accommodation of the soft parts of the animal.

The Lima—sometimes called the Sea-butterfly—has a shape somewhat resembling that of a mussel, but is of a beautiful white colour. Here we have an interesting example of a nest-building habit, the adult animal spinning together grains of sand, coral fragments, and shells, which are bound together by a mass of threads formed from a natural secretion. Writing of this curious habit, Mr. D. Landsborough states:—"The nest is curiously constructed, and remarkably well fitted to be a safe residence for this beautiful animal. The fragile shell does not nearly cover the Mollusc, the most delicate part of it, a beautiful orange fringe-work, being altogether outside the shell. Had it no extra protection, the half-exposed animal would be a tempting mouthful—quite a *bonne bouche* to some prowling haddock or whiting. It is not content with hiding itself among the loose coral, for the first rude wave might lay it naked and bare. It becomes a marine mason, and builds a house or nest. It chooses to dwell in a coral grotto; but in constructing this grotto it shows that it is not only a mason, but a rope spinner, and a tapestry weaver, and a plasterer. Were it merely a mason, it would be no easy matter to cause the polymorphous coral to cohere. Cordage, then, is necessary to bind together the angular fragments of the coral,

The Shell-builders.

and this cordage it spins ; but it spins it as one of the secrets of the deep. Somehow or other, though it has no hand, it contrives to intertwine this yarn which it has formed among the numerous bits of coral, so as firmly to bind a handful of it together. Externally, this habitation is rough, and therefore better fitted to elude or to ward off enemies. But though rough externally, within all is smooth and lubricous ; for the fine yarn is woven into a lining of tapestry, and the interstices are filled up with a fine slime, so that it is smooth as plaster work. When the Lima is taken out of its nest and put into a jar of sea water, it is one of the most beautiful marine animals you can look upon. The shell is beautiful ; the body of the animal within the shell is beautiful ; and the orange fringe-work outside the shell is highly ornamental. Its mode of swimming is the same as that of the scallop. It opens its valves, and, suddenly shutting them, expels the water, so that it is impelled onwards and upwards ; and when the impulse thus given is spent, it repeats the operation, and thus moves on by a succession of jumps. When moving through the water in this way, the reddish fringe-work is like the tail of a fiery comet."

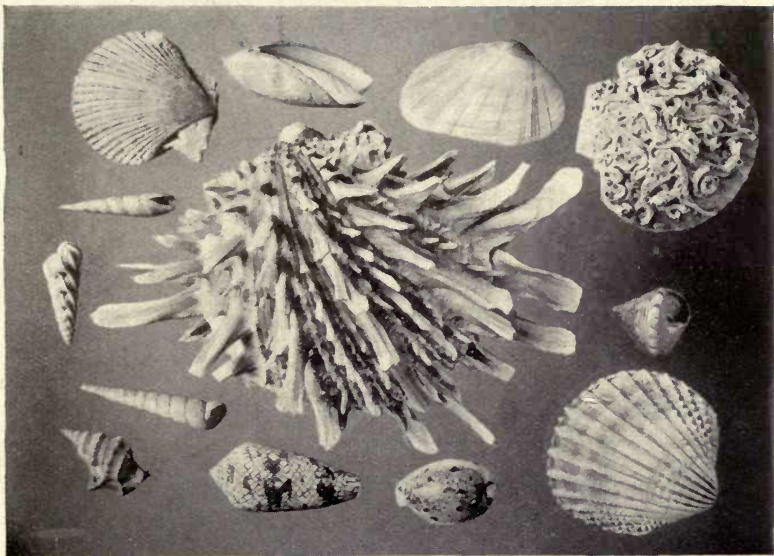
Many of the bivalves are miners, digging down deeply into the sand, beneath which they can live safely and undisturbed by hungry foes. Of these burrowers the Cockle is a familiar example, living in sandy bays or sand banks where digging operations can be swiftly and easily performed. It is its long, strong foot which the Cockle employs as a spade. Thrusting the pointed tip into the yielding sand, the Cockle pushes its foot down as far as it will go ; then, bending the end into

How Animals Work.

a hook and so fixing it firmly in the ground, it drags itself, shell and all, beneath the surface. Not only as a spade to dig an underground domicile, however, does the Cockle use its powerful foot, for when on the surface of the sand the little Mollusc can progress towards the incoming tide by a series of leaps and bounds, by pressing its foot firmly against the ground, bending it, and then letting it go so that it acts as a spring.

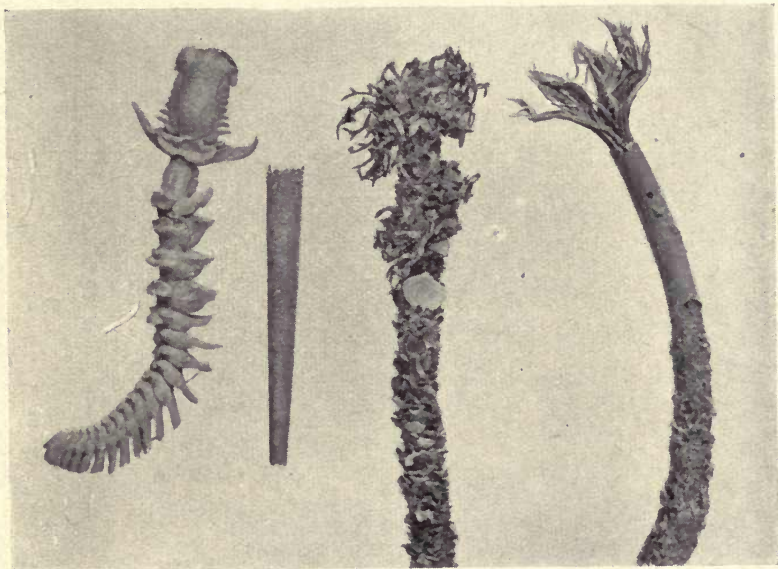
One of the most interesting of the mining Molluscs is the *Solen*, or Razor-shell, which excavates a vertical tunnel in the sand in which to live, quite low down on the shore, so that the entrance to its burrow is only exposed at low spring tides. Again, as in the cockle, it is the powerful foot which the *Solen* employs in digging its vertical retreat, and the process is a very interesting one to watch. Suppose the *Solen* to be resting on the surface of the wet sand, the animal will cautiously push out its foot from the safe shelter of the long razor-case-like valves of its shell, and feel about for a soft spot; then the pointed tip of the foot is thrust into the sand, the prone shell is pulled into an upright position, and gradually, by a series of jerks, disappears from view, an oval keyhole-shaped opening on the surface of the sand marking the entrance to the vertical burrow. The way in which the *Solen* uses its foot to drag itself down the shaft is really very remarkable. When first pushed into the sand the foot is flat and sharply pointed at its tip, so that it slips easily into the soft moist sand. Then, when it has been forced down as far as it will reach, the animal curves up its toe to form a sort of hook with which it

PLATE V.



A GROUP OF SHELLS.

On the back of one a colony of marine-worms have built their tubes.



A GROUP OF MARINE TUBE-BUILDING WORMS.

The Shell-builders.

grips the sand firmly while the long shell is hauled into the entrance of the burrow. Pointing its toe once more, the Solen elongates it and dives it still further down, the end of the foot suddenly swelling out until it becomes firmly wedged in the shaft, while the upper part contracts, dragging the shell downwards with a jerk. In this way, by alternately contracting and plunging its toe downwards and then expanding it, the Solen excavates the long, narrow shaft, at the bottom of which it spends most of its life.

A number of bivalve Molluscs are expert masons, excavating chambers in the rock in which to dwell. One that is to be found on almost any rocky shore is the *Pholas*, or "Piddock" as it is popularly called on many coasts. It is a small animal, with a pair of milk-white shells which are very thin and brittle, and do not completely cover the Mollusc. As soon as its shell is formed, the young *Pholas* proceeds to excavate for itself a rocky cave, large enough to make a comfortable dwelling-place, but too small for its enemies to enter. There it spends the rest of its life, a willing hermit in a rock grotto, the interior of which it gradually enlarges to meet the requirements of its own increase in size. For many years the way in which the *Pholas* excavated its home in the rocks was a sore puzzle, and many were the theories, more or less dogmatically expounded, as to how it was accomplished, such as the possession of an acid corroding fluid that gradually dissolved the rock away; or that the *Pholas* scraped away at the rock with the edges of the valves of its shell, turning round and round the while like a living drill. Although the valves are beset with

How Animals Work.

inequalities producing a rasp-like structure, it is chiefly by means of its foot, the base of which is furnished with a layer of renewable sharp flinty crystals, that the *Pholas* excavates its cave, but the exact manner in which it is accomplished is still imperfectly understood.

Saxicava is another bivalve mason, excavating tunnels often six inches in length, so that limestone rocks on the coast are sometimes riddled with the borings of this small, thin-shelled bivalve. It by no means confines its attention to the rocks and reefs unfortunately, but will also make its home in the base of stonework piers and breakwaters, boring into the concrete cement and stone used for building such structures.

The Date-shell (*Lithodomus*), related to the edible mussel, makes excavations in corals and hard limestone rocks. At Puteoli, on the shores of the Mediterranean Sea, stand the ruins of the temple of Serapis. Three erect white marble columns are still standing, and these are perforated at a height of nearly twenty feet above the present sea-level with the excavations of the Date-shell. Similar borings at the same height are to be seen in the face of the cliffs near by, and afford most striking evidence of the changes which have taken place in the level of the land within historical times. The temple, originally built on dry land, must with the cliffs have been submerged to a depth of over thirteen feet beneath the surface of the sea for an appreciable period of time, during which the Date-shells made their excavations, and then gradually the land was once more raised to its present level.

CHAPTER IV.

SOME CURIOUS TUBE-BUILDERS.

MANY of the worms that are dwellers in the sea are most expert builders, constructing remarkable tubular dwellings out of particles of sand, fragments of shell, and even fine mud, in which to live. These marine worms are all much handsomer and more complex animals than their humbler land relations the earth worms, and possess special organs for collecting the materials out of which they construct their tubes.

A familiar object, often to be found at the bottom of a rock pool on the seashore, is an old whelk shell, upon the back of which may be seen a number of long shelly tubes, more or less bent into curves, and firmly attached by their sides to the whelk shell. Small and closed at one end, they increase in diameter towards the mouth or open end, and are considerably longer than the worms which formed and inhabit them, and are marked at irregular intervals with encircling ridges, each ridge representing a period of growth. The worm which forms this tube is called the *Serpula*, and is a most interesting and handsome little creature. The tube is built for the protection of the soft body from hungry foes, as well as for a dwelling-place, and

How Animals Work.

therefore, if we watch a tube in a rock pool, we shall see that it is only the head and a tuft of special organs that are thrust out at the opening of the tube from time to time. The gill-tufts, which form the breathing apparatus of the *Serpula*, are all close to the head ; while one of the gill filaments has become modified into a long, conical-shaped, brightly tinted operculum, or trap door, for closing the entrance to the tube against unwelcome visitors. The effect produced, as the *Serpula* cautiously pushes its head out of its tube, is rather like that of a very gorgeous sweep's broom appearing out of the top of a chimney. Directly the gills are pushed up outside the tube, they spread out in the shape of broad plume-like fans on either side of the gaily tinted operculum. These plume-like organs are composed of delicate bright red, slender filaments placed side by side on the supporting stem, like the teeth on a comb. The filaments are clothed with countless waving hairs, or cilia, which are so arranged as to produce by their movements an upward current along one side of each filament and a downward current on the other side. This wonderful mechanism ensures not only a constant supply of fresh sea water passing over the gills so that the blood of the *Serpula* is kept aerated and purified, but these same inward-flowing currents pass down the funnel formed by the base of the fans and operculum, carrying directly to the mouth of the *Serpula* the minute animals and particles of animal and plant matter upon which it feeds, and from which the supply of living material for the secretion of the shelly tube is partly obtained.

A group of these worms, with their fans fully ex-

Some Curious Tube-builders.

panded and gently swaying in the clear water, presents a most charming appearance. A shadow passing over, or a ripple on the surface of the pool, and in a flash every head has disappeared within its tube and no sign of life or animation remains. To enable it to make so startlingly abrupt a descent into the safe recesses of its tubular home, the *Serpula* is provided with a very remarkable piece of apparatus consisting of four rows of tiny hook-like appendages on various rings of the body, shaped something like hedgers' little bill-hooks with their edges cut into long teeth. These little hooks are exceedingly minute, a magnifying power of three hundred diameters being necessary to show all the structure clearly under the microscope. The late Mr. P. H. Gosse calculated that the *Serpula* has about nineteen hundred of these hooks, each hook being cut into seven teeth, so that something like thirteen thousand to fourteen thousand tiny teeth catch on to the lining of the tube to drag the worm down when it suddenly disappears from view; altogether, a most wonderful contrivance for safe and rapid retreat.

The Fan *Sabella* is an interesting little mason worm of the seashore, delighting in situations where there is a mixture of sand and mud; and on such a stretch of shore at extreme low tide one may often find a forest of little tubes sticking up two or three inches above the surface, composed of grains of sand and mud cemented together. Beneath the surface these tubes extend to a depth of eight or ten inches, the total length of the tube averaging about twelve inches.

Of the manner in which the Fan *Sabella* constructs its tube, that fine old naturalist Sir John Dalyell has

How Animals Work.

left the following account:—"Let a tall and ample crystal jar containing a *Sabella* be emptied of its contents and speedily replenished with sea water: the animal, if in view, has retreated during the short interval; the orifice of the tube is closed; all is at rest. But soon after replenishment it rises, to display its branchial plume still more vigorously than before, and remains stationary, as if enjoying the freshness of the renovated element, always so grateful—the har-binger of health and strength to those whose dwelling is there. The passing spectator would conclude that he now beholds only a beautiful flower, completely expanded, inclining towards the light like some of those ornaments of nature decorating our gardens. He pauses in admiration. But if a drop of liquid mud falls amidst the element from above, disturbing its purity, then, while the plume unfolds to its utmost capacity, does the animal commence a slow revolution, the body also passing around within the tube. Now are the thousands of cilia fringing the ribs of the branchiæ (plumes) discovered to be in vigorous activity, and their office to be wondrous. A loose muddy mass is seen afterwards visibly accumulating in the bottom of the funnel; meantime the neck, or first segment of the body, rising unusually high above the orifice of the tube, exhibits two trowels beating down the thin edge as they fold and clasp over the margin, like our fingers pressing a flattened cake against the palm of the hand.* During these operations muddy collections are seen descending between the roots of the fans

* The trowels are the lappets of the collar encircling the base of the plumes.

Some Curious Tube-builders.

towards the trowels, while another organ, perhaps the mouth, is also occupied, it may be, in compounding the preparation with adhesive matter. Still does the partial or complete revolution of the plume above, and of the body within the tube, continue; the bulk of the muddy mass diminishes, activity abates; it is succeeded by repose, when the tube is found to have received evident prolongation."

Though not such a handsome worm as the Fan Sabella, the little "Sand-mason" worm builds a far more elaborate tube, using grains of sand, small pebbles, and fragments of shell in its construction. The Sand-mason worm has upon its head a large number of long thread-like feelers arranged about its mouth, each feeler having a groove running down its whole length, while the gills are short, branched, and restricted to two or three pairs in number. The very slender feelers, or tentacles, can be extended for a surprisingly long distance, and are used by the Sand-mason in collecting the materials for constructing its tube. When one of these tentacles in sweeping about grasps a fragment of shell or a grain of sand, the object may be seen to travel along the groove, running down the entire length of the tentacle, until it reaches the mouth of the worm. The little Sand-mason takes in turn each fragment so obtained into its mouth, and then the grain of sand or fragment of shell, as the case may be, is apparently moistened with some sort of adhesive secretion, and is then ejected and placed in position on the edge of the tube, being arranged in its place by the lips of the worm. With tireless energy, grain by grain is collected by the little Sand-mason and

How Animals Work.

placed in position in the process of building its tubular home, decorating its outer surface with gleaming pearly fragments of shell, and crowning the whole with a wonderful network of branches which help to support the long and slender tentacles when they are extended.

The completed home of the Sand-mason is really a very remarkable structure, and to watch the little artisan at work upon its erection is a most interesting occupation, and one which almost any visitor to the seaside may, with a little care and trouble, witness for himself. The Sand-mason worm may be found at extreme low tide on sandy shores where there is an admixture of fragments of shell; the tubes, crowned by these spreading branches, sticking up out of the sand like a miniature forest, should the situation be favourable. Now it is quite possible, with the exercise of a little care and patience, to dig up one or two tubes with their tenants inside, and to take them home in a large jar of clear sea water. If one of the tubes is carefully opened, the worm may be gently taken out and placed in another glass jar filled with sea water. The Sand-mason will at first go through the most astonishingly rapid contortions, at last sinking to the bottom of the jar exhausted. Now is the time to scatter a small quantity of sand and shell fragments on to the bottom of the jar, when the Sand-mason will at once begin to extend its tentacles in all directions, and begin upon the business of constructing a new house.

A most extraordinary tube-builder is the Varied-footed Worm (*Chætopterus variopedatus*), which may sometimes be found at lowest tide mark on the shore,

Some Curious Tube-builders.

where there is a mixture of sand and oozy mud. The worm measures about six to eight inches in length, and is of a creamy white colour, except in the region of the stomach, which is generally a darkish green colour. The marine worms are most remarkable in their appearance, many of them to the uninitiated looking singularly unwormlike; but even in this strange assembly the Varied-footed Worm stands out conspicuously as one of the most grotesque in shape. Indeed, it looks like a sort of nightmare animal, a creature whose front part has a freakish resemblance to the head of a cow, while the rest of the body might do duty for that of a pantomime caterpillar. This weird-looking creature is quite an expert builder in its way, and constructs a tube of parchment-like texture, coated externally with sand and small pebbles, which is of ample proportions and generally about two feet in length. This tube is buried in the oozy mud and sand in the shape of a capital letter U, both ends projecting above the surface of the sand for about a couple of inches. Sometimes one end of the tube is divided into two or three branches, which appear to have been added later, probably to serve as auxiliary openings, the original opening having become blocked up. This strange worm becomes beautifully phosphorescent at night, so that the entrance to its tube is strangely luminous, as if soft bluish fires lurked within.

A little marine worm, which is sometimes called the "Golden-head" by the fisher folk (its scientific name is *Pectinaria auricoma*), and which may be found on sandy shores at extreme low tide, builds a remarkably neat house. This little Mason worm constructs a very

How Animals Work.

delicate tube, as thin as paper, composed entirely of grains of sand which have been most carefully selected, and cemented together by a natural and copious secretion. The walls of the slightly conical and curved tube do not exceed a single grain of sand in thickness, they are beautifully smooth without, and are lined within with a thin silky film of secretion. Building operations are generally carried on at night, for Golden-head is a shy little fellow; but when engaged in lengthening or repairing his tube, he spreads his tentacles abroad, gathering and selecting sand grains of a given size, rejecting all others that may come to hand, moistening each grain with cement ere placing it in position. The finished tube is open at both ends, and the little worm carries it along when moving over the floor of the sea.

But now I would ask you to quit the seashore for a while, leaving its wealth of marvellous forms of animal life, that we may journey inland and visit some quiet, reed-bordered fish pond, whose surface, diapered with the leaves of many a water plant, reflects the image of the overhanging willows and the soft white clouds that sail like silver argosies across the summer sky. Beneath the surface of that quiet pool, could we descend (and at the same time diminish in size until we dwindled to the microscopic proportions of its smaller inhabitants but still retained our powers of vision and understanding), what a strange world we should enter—a world peopled by “creatures that swim with their hair, that have ruby eyes blazing deep in their necks, with telescopic limbs that now are withdrawn wholly within their bodies and now stretched

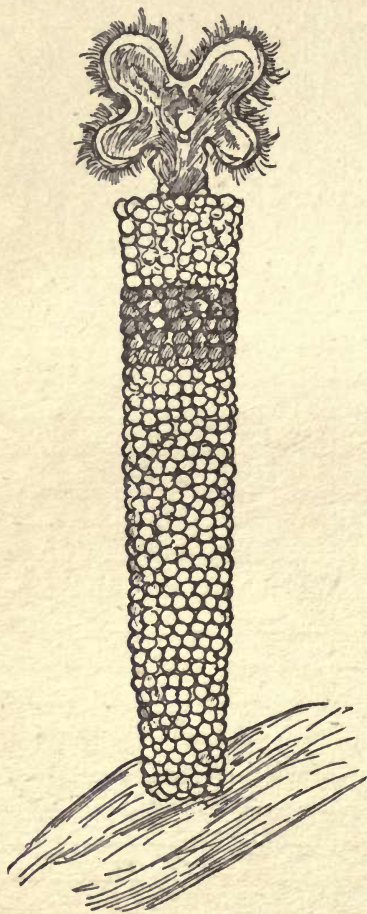
Some Curious Tube-builders.

out to many times their own length. Here are some riding at anchor, moored by delicate threads spun from their toes ; and there are others flashing by in a glass armour, bristling with sharp spikes or ornamented with bosses and flowing curves ; while, fastened to a green stem, is an animal convolvulus that by some invisible power draws a never-ceasing stream of victims into its gaping cup, and tears them to death with hooked jaws deep down within its body." While it is impossible to take this idealistic plunge beneath the surface, it is quite possible, with the help of collecting bottle and microscope, to bring the strange denizens of this pond within the range of our vision, and that is what we will now proceed to do.

Attached to the submerged stems and leaves of water plants may often be found a microscopic builder of singular beauty and interest. To the unaided eye, the little tower within which this creature dwells looks like a tiny stump about one-sixteenth to one-thirty-second of an inch in length fixed at one end to the surface of the leaf or plant stem. On placing a leaf to which one of these tubes is attached in a watch glass or shallow cell filled with water, and examining it under the microscope, we shall find that the little stump, now greatly magnified, is really quite a beautiful object, and composed of numerous round pellets placed in regular rows one on top of the other, like rows of circular bricks. This is the home of the *Melicerta*, the Brick-maker Rotifer. As we look at the rows of neatly arranged bricks or pellets, the head of the Rotifer begins cautiously to appear above the edge of its tower, and then it suddenly thrusts forth and expands before

How Animals Work.

our enchanted gaze like a beautiful silvery pansy blossom. But how infinitely more wonderful than the petals of that charming flower of our gardens are the



Brick-making Rotifer.

petal-like lobes of *Melicerta* the Brick-maker, for they are fringed with stout pointed hairs, or cilia, which, by their constant rhythmical motion in one direction, make each petal-lobe appear to rotate like miniature toothed cog-wheels; and it is from this wheel-like appearance of the lobes that *Melicerta* and its numerous interesting relations have received their class name of Rotifera (from the Latin *rota*, a wheel, and *fero*, I bear), or Wheel-bearers.

As *Melicerta* protrudes itself from the top of its little tower, it appears a somewhat complicated mass of transparent flesh, involved in many folds, with at one side a pair of hooked spines, and at the other two slender, short, blunt processes which project horizontally. As the little Rotifer continues to push upwards from its tube, suddenly two large upstanding and two smaller down-

Some Curious Tube-builders.

ward-directed petal-like discs are expanded, and a wreath of cilia in active motion is seen to fringe them. Below the large petal lobes there is a projecting angular chin, which is also clothed with cilia ; and immediately below this is the little organ with which *Melicerta* forms the bricks or pellets to build its house. This apparatus appears to form a small hemispherical cup, and is capable of being projected forward on its short stalk. Now the little Brick-maker forms the pellets for its house out of the excess of food particles which float in the surrounding water, and which are brought within its reach by the currents set up by the vibrating wreaths of cilia. These particles can be seen whirling round the petal-like lobes caught in the current of the waving cilia, and are carried down to minute channels on either side of the projecting chin through which they pass into the cilia-clad glandular cup, which is really mixing-chamber and mould in one. Here the particles, as they revolve, are cemented together into a pellet or brick ; and when the operation is completed, *Melicerta* bends its head forward, and the moulded brick passes from the cup in which it was formed on to the rim of the tower. In this fashion, brick after brick is "well and truly laid" in position, and so the little tower increases in height. It is quite possible to keep *Melicerta* in a healthy, active condition for some time in a small trough, and by supplying the little Rotifer with plant-food particles (which must be very finely ground and only a very small quantity given) of different colours, or with particles of carmine, to induce it to build a tube of various bands of colour.

How Animals Work.

In collecting the water weeds to which *Melicerta* attaches its tube, we are very likely to gather some of those strange aquatic insects called Caddis-worms, which delight to clothe their soft and otherwise unprotected bodies in garments composed of all sorts of odds and ends of plant and animal remains (*b*, Plate VI.). They vary a great deal in their choice of materials and perfection of workmanship, some appearing to be singularly slovenly and untidy, weaving together a perfect jumble of bits of dead leaves and twigs of all shapes and sizes into a rough more or less tubular garment. There is method in their madness, however, for probably their untidy clothes, when the insect suddenly withdraws within them and remains quiescent, look far more like part of the natural debris of the bottom of the pond than do the more tidy and symmetrical productions of some of their relations. A very large proportion of the Caddis larvæ collect pieces of leaves or the small stems of water plants, which they fasten together with a natural silky secretion, sometimes lining the whole tube or case with silk ; but there are several who form their tubes out of grains of sand, particles of earth, and small stones, and one is particularly fond of collecting the tiniest of water-snail shells, which it attaches on to its case with a blissful disregard as to whether the shell is still tenanted or not, so that a poor baby water snail may often be seen, upside down, an unwilling captive on top of the tubular case of this Caddis larva. It appears at first perhaps a strange habit, this collecting together of materials so diverse, and their formation into a tubular portable dwelling or garment. But we must remember that although

Some Curious Tube-builders.

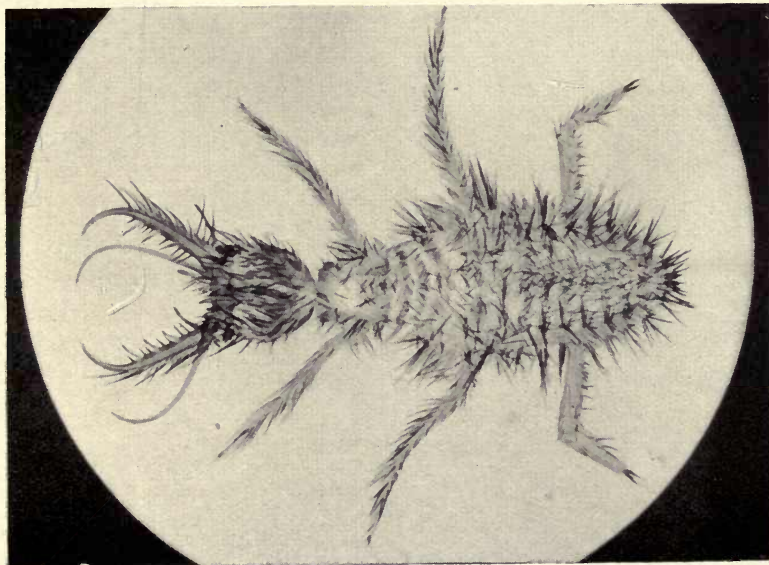
the Caddis larva has a fairly hard head and legs, its body is soft, plump, and altogether a toothsome sort of morsel for many a hungry denizen of the pond; and so this habit is really a necessity, a means of hiding from view and protecting the soft, defenceless body.

CHAPTER V.

FISH AS NEST-BUILDERS.

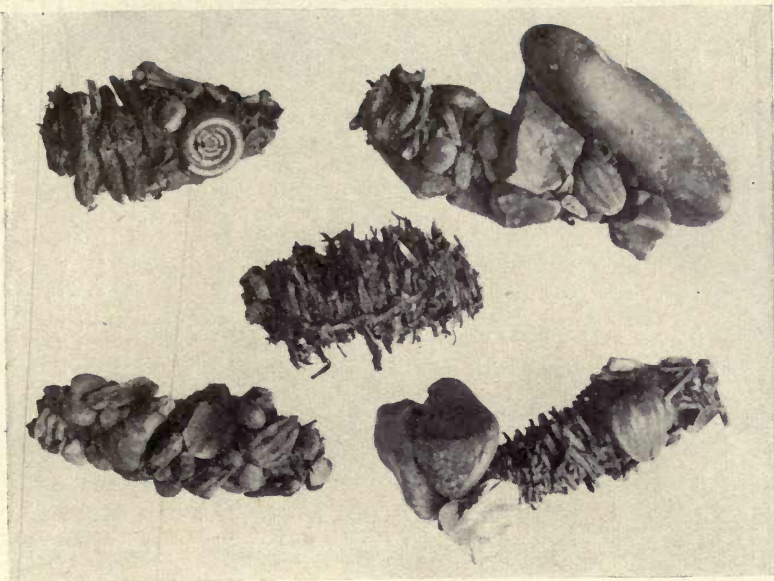
THE idea of a fish acting as a master-builder sounds, perhaps, rather astonishing and unlikely, but there are one or two very interesting examples to be met with among both fresh-water and marine fishes. They cannot be said to erect very stately or lasting structures, for their building operations are confined to the construction of nests to hold their spawn; and once the young are hatched and have made their escape, the frail structure soon falls into ruin and total disintegration.

I will first deal with the little Stickleback, which is a familiar denizen of our streams and larger ponds, and a most able nest-builder. Quite early in the year the male Stickleback begins to seek for what he considers a favourable building site at the bottom of the pond or stream which he inhabits, and should he find another male already occupying the coveted site, a most desperate encounter ensues, the rivals attacking each other not only with their mouths, but with the three sharp erectile spines upon the back. The victor then enters into possession, his vanquished opponent slinking sorrowfully away. But the victor may not be allowed to rest on his laurels in undisputed enjoyment of his newly



THE ANT-LION LARVA.

An expert in the art of digging pitfalls.



STRANGE HOUSES.

Composed of twigs, stones, and pond-snails; built by Caddis-worms.

Fish as Nest-builders.

acquired possessions ; for, should the site be a peculiarly attractive one, other males will challenge his right to it, and a series of combats will be fought over it until the strongest and boldest male gains permanent possession. Having successfully driven off all rival claimants, the little Stickleback proceeds to dig foundations and collect building materials. The foundations take the form of a shallow depression in the sandy soil, which the Stickleback makes by rolling his body about thereon. Then he begins to collect delicate vegetable fibres, selecting the smallest stems and root-lets of various water weeds, placing them longitudinally in the hollow already excavated for their reception, and securing them in position by a secretion of mucus from his skin. The floor of the nest completed, the little builder proceeds with the erection of the walls, using the same materials as employed for the floor, leaving a small opening or door, finally crowning the whole with a roof of similar material.

By the time that the nest-building operations are completed, the little Stickleback has attained the full glory of his spring colouring : he has donned his courting dress, and is a most resplendent object, his breast and throat mantled with scarlet hues, while his sides shine and flash with metallic lustre. Off he starts to seek a suitable bride. And here again we find his lordship somewhat critical and hard to please. By no means does he pay court to the first little lady Stickleback that may chance to cross his path, and he may inspect and even carry on a mild flirtation with several before he finds one to fulfil his ideals. In this selection he is probably seeking for one whose ova are ripe for spawning. The fair

How Animals Work.

object of his desires discovered, the little Stickleback at once returns with her to the neighbourhood of the nest. Then a great deal of fussing and coaxing takes place; for the little lady fish is coy, or does not quite approve the appearance of the nest, and at first declines to enter. The little male grows tremendously excited at her reluctance to comply with his wishes, glowing with colour, hovering over and half entering the nest, as if to show her the way in, and then setting up the spines on his back and dashing about in a most agitating way. This latter performance generally has the desired effect, and, half persuaded, half driven, the little female at last enters the nest. Her stay within that neatly-made structure, however, is by no means a lengthy one; for she only remains long enough to lay a few yellow eggs therein, and then immediately departs.

The little male now enters the nest to examine and fertilize the eggs, and then comes forth to spend the rest of the day in short encounters with any males that dare to approach. Next morning he is up betimes and away in search of his lady-love, who is not always the lady of the previous day. Indeed, two or three different females may each in turn be brought home to provide the full complement of eggs for the nest. Once this is accomplished, the little male closes the entrance to the nest, and, taking up his position outside, mounts guard, fiercely driving away all intruders, including the mothers of his family, should they deign to approach. For some ten to thirty days, according to the temperature of the water, the little fish keeps watch and ward over the nest, which

Fish as Nest-builders.

from time to time he enters to make sure that all is well within, vibrating his fins the while so as to produce a current of water through the nest to aerate the spawn. All this time the mothers take not the least heed of what is going on; in fact, they are conspicuous by their absence from this scene of domesticity, having gone off to enjoy themselves, and it is the industrious little male who brings up the family. Indeed, should some accident overtake him during his guardianship, the nest will at once be torn to pieces by other Sticklebacks and its precious contents devoured. The parental labours do not terminate with the hatching of the spawn, for the male keeps his offspring safely confined to the nest for about a week after their hatching, until they have grown to about three or four millimetres in length, when he pulls the nest to pieces and permits his family to come forth.

The marine Stickleback, sometimes called the Sea-adder, is rather larger than the fresh-water species, attaining to a length of from six to eight inches; and not only does it build a nest, but it binds the materials together with silky threads spun from its own body. "The nest," writes Professor J. T. Cunningham, "consists of growing seaweeds, and the kidneys of the male in the breeding season secrete a gelatinous substance which hardens as it is drawn out into a strong, white, continuous fibre, and this is wound about and woven into the nest as the fish swims about it during its construction. This fish, therefore, may be said to spin a cocoon somewhat in the same manner as a silkworm or other caterpillar. The sea Stickleback affords the only instance of spinning among the vertebrates of

How Animals Work.

which we have certain knowledge." The Stickleback appears either to find a suitable growing tuft of seaweed in which to build, or to collect together some of the soft threads of green or red seaweeds, joining them to the stouter fronds of coralline growing on the rocks so as to give the structure additional firmness and stability, the whole being woven together by the silky threads spun from the secretion of the kidneys. When completed the nest is somewhat pear-shaped, and some five or six inches in length. In this remarkable structure the female deposits her eggs, and then departs, leaving the male fish to mount guard over the nest until the young hatch and make their escape.

Several tropical fishes are very expert builders, and one, called *Gymnarchus*, constructs a very large floating nest of grasses, about two feet long by twelve inches wide. Three sides of this remarkable nest project above the surface of the water, while the fourth side is about two inches and the bottom about six inches beneath the surface. According to the natives, the parent fish guards the nest until the young are hatched and make their escape. Another African fish, the *Heterotis*, makes a nest some four feet in diameter, enclosed by walls eight inches thick, made of grasses which the fish removes from the interior so as to have the bottom composed of the smooth, bare ground of the swamp.

The Chinese Paradise-fish constructs a most remarkable floating nest literally composed of air bubbles. In the breeding season the little male who constructs this nest is resplendent in bluish green, with bands of red and patches of orange. He may be seen to rise to the

Fish as Nest-builders.

surface of the water and suck in a mouthful of air. He holds this in his mouth for a while, and then permits it to escape and rise to the surface of the water in the form of a bubble. This process is repeated again and again, until a regular collection of bubbles has been formed, all clinging together in a mass some three or four inches in diameter. The bubbles do not burst, for each one as it was formed within the mouth of the little fish received a coating of slime or mucus secreted by special glands, so that they are really miniature bladders more than bubbles, stuck closely together. Having completed this strange nest, the little Paradise-fish goes forth in search of a wife, and soon returns with her, and induces her to spawn beneath the shelter of the raft-nest.

The eggs of the Paradise-fish are very buoyant, so that as they leave the female they do not sink, but float upward and stick to the under surface of the raft-nest. All the time that the little female is depositing her eggs, the male is in a great state of excitement and watchfulness, in case any of the precious eggs should go astray; and should one float away beyond the nest, he will at once give chase, and bring it safely back in his mouth, like a dog returning a lost ball. He is by no means contented with one wife, and several females will be brought in succession to deposit their spawn beneath the raft-nest, until some five hundred eggs may be collected beneath it. Then, like the male Stickleback, the little male Paradise-fish mounts guard while the ladies depart to enjoy themselves. Not for one instant does the devoted little fellow neglect his duty, and it is very pretty to see with what care he tends the eggs,

How Animals Work.

moving them about, bringing those in the centre to the outside, and transferring those which were outside towards the middle, so that all shall constantly be in fresh water. When the eggs at last hatch, he then mounts guard over his offspring, keeping the fry well together under the safe shadow of the raft-nest, and bringing back any that may wander outside its boundary. Not until the young fish can swim freely does he relax his vigilance and permit them to depart from the shelter of the nest.

A still more remarkable nest is built by the Rainbow-fish, which lives in the rivers of Northern India and is common in the Ganges and the Jumna. As its popular name denotes, it is a very handsome fish, its body brilliantly coloured with bands of scarlet and light blue. The male Rainbow-fish also builds a floating nest, but it is not composed of air bubbles like that of the Paradise-fish, and is a much more complex affair. This little fish selects the delicate, slender threads of those hair-like water plants called *confervæ*, which are to be found growing in almost every pond and sluggish stream. These threadlike plants are just a trifle heavier than the surrounding water, and therefore are to be found drifting at a little distance below the surface, if there is any current to carry them along, or resting on the river bottom. When about to build his nest, the little Rainbow-fish rises to the surface and takes in a mouthful of air, very much after the fashion of the Paradise-fish ; but instead of forming it into one large bubble, he converts it into a number of tiny ones, which he proceeds to expel from his mouth in such a manner that they become entangled in some of the floating threads of *confervæ*, and carry

Fish as Nest-builders.

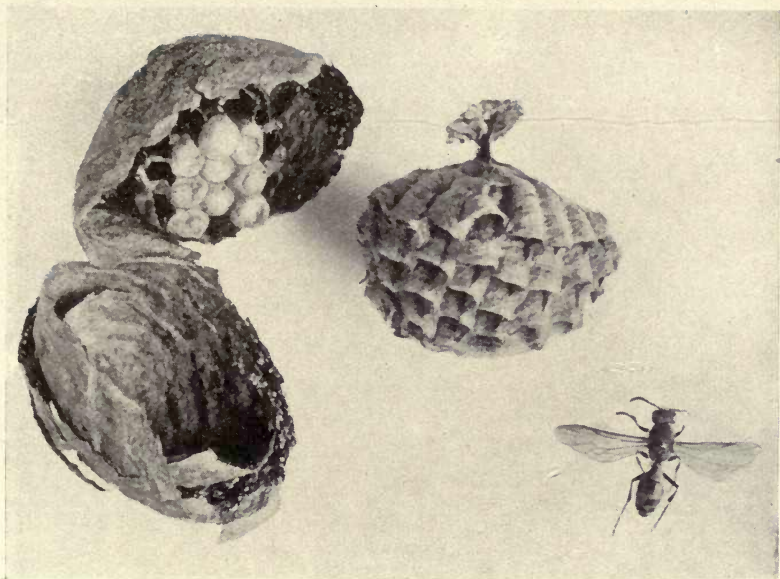
them up to the surface. This process is repeated several times, until the little fish has got together sufficient threads to start weaving his raft. When he has woven together a mass of threads about an inch in diameter, he rises to the surface, takes in a large gulp of air, and, without enclosing it in mucus after the manner of the Paradise-fish, liberates it beneath the raft which he is in process of weaving, and which is thus buoyed up. Off he goes in search of more plant threads, and these as they are collected are fastened alongside the first, until the whole mass measures some four inches in diameter. Once more he ceases from weaving, and pays a succession of visits to the surface to collect more air to liberate it beneath the raft, until the middle begins to rise as a tiny green rounded dome, some two inches above the surface of the water. More confervæ are now collected and placed around the dome, and carefully and stoutly woven into place, like a broad flat brim sewn on to the crown of a dome-shaped hat.

This remarkable raft-nest completed, the little Rainbow-fish escorts a series of females beneath it, so that their floating eggs are placed beneath the shelter of the dome. He then mounts guard and tends the eggs, in very much the fashion of the Paradise-fish, for about three days, and then, that the eggs may be completely surrounded with water and the young successfully hatched from them, he makes a hole in the top of the nest and lets the imprisoned air escape, with the result that the dome falls in, and both raft-nest and eggs sink gently down to the bottom. As soon as the young hatch out, the little Rainbow-fish proceeds to undo the firmly woven edge of the nest, and ravel it out until

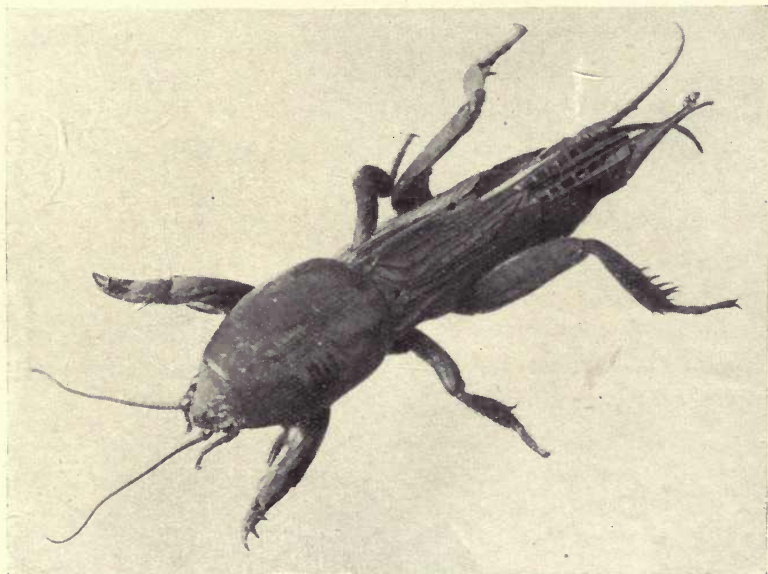
How Animals Work.

a regular fringing curtain hangs down all round and forms a most successful barrier to the escape of the little ones, who are thus kept snug at home until they are strong enough to lead independent lives, when they swim away to fend for themselves.

PLATE VII.



TYPES OF TREE-WASP NESTS.



THE MOLE CRICKET.

One of the most expert miners of the insect world.

CHAPTER VI.

WONDERS OF INSECT ARCHITECTURE: SOCIAL BUILDERS.

FROM the insect world we may obtain many striking examples of constructive ability, and the erection of wonderful dwellings for the protection of the defenceless young and the storage of food supplies.

Few people have a good word for the Common Wasp, and yet, despite her somewhat irritable temper and her propensity to use her sting at the slightest provocation, she is really a valuable friend to man, and more particularly to the dweller in large towns and cities, for she destroys quantities of house-flies. Now any creature that will destroy the house-fly is doing invaluable service to the town-dweller, for there is no more fruitful distributor of disease germs in our cities than that buzzing, ubiquitous insect. Breeding amidst all sorts of decaying refuse, the adult fly delights to feast upon the filth and garbage of the street, loading its hairy body and limbs with all sorts of disease germs. Fresh from its noisome repast, it will fly in at the open window and take an involuntary bath in the milk jug, or creep about over any food that may be exposed upon the table, in this way carrying disease germs to our food supply. Indeed, the appalling infant mortality

How Animals Work.

during the hot summer months in the crowded slums of our large industrial cities is largely due to infection being carried from house to house, and from room to room, by the house-fly. Now, if you will watch the wasps, leaving them undisturbed, you may see how they will hover about the garden or a room, pouncing upon the flies and carrying them off in triumph, only to return a few moments later in search of more. Indeed, standing one hot summer afternoon in a typical squalid street of one of our towns, looking at the black masses of flies that were swarming over the various articles of food exposed for sale on the slab of an open shop front, my attention was attracted to a constant stream of wasps, going and coming with the greatest regularity, each departing wasp carrying off a captured fly. As on the average one wasp arrived and promptly pounced upon a fly every fifteen seconds, it was a most convincing demonstration of the value of the wasp in helping to destroy the horrible, disease-spreading house-fly.

But now let us consider the Common Wasp as an architect and builder. The nest is really a very remarkable structure, more or less globular in shape, and generally hidden underground, in some wayside bank or hedgerow. The Queen Wasp is the foundress of the nest, and the whole structure is built up in a comparatively short space of time, the close of the autumn seeing the death of its teeming inhabitants; for the wasps do not lay up stores of food and continue as a permanent community year after year, like their cousins the hive bees. The first really warm days of spring see the Queen Wasp coming forth from some snug retreat where she has slept through the long, cold,

Wonders of Insect Architecture.

dark winter months, safe out of reach of the frosts. She stretches her cramped limbs in the glad warmth of the spring sunshine, rubs herself down and washes her face with the aid of her slender legs, and then, with a flutter of her small but powerful wings, darts off into the garden. Follow her, and we find that she has not gone very far afield, but is anxiously and thoroughly exploring every foot of the sunny bank of the hedge. She enters one small hole after another, only to quickly reappear with a little dissatisfied buzz; for she is in the throes of house, or rather site, hunting, seeking for a suitable position for the erection of her nest. At last she disappears down a somewhat larger hole, perhaps the entry to a deserted burrow of a field-mouse, and remains out of view for some minutes. Returning to the surface, she pops her head out, looks eagerly all round, and then, as if satisfied with the general surroundings as viewed from the dark entry, emerges and once again proceeds with her toilet. It is only a momentary rest—a feminine sign of satisfaction at the final selection of the building site. Once more she disappears through the hole in the bank, and could we follow her we should see that she is busy within breaking away the soil, clearing away the debris, which she brings to the surface piecemeal, until she has fashioned a chamber to meet her immediate requirements. Then out into the sunlight once more, and a few seconds spent in vigorous toilet operations to rid her body and limbs of any clinging particles of dirt, and then away on swiftly vibrating wings to the nearest old wooden weathered fence that she can find. Every seasoned paling is carefully examined, tapped by quiver-

How Animals Work.

ing antennæ, tested by eager jaws, until a suitable place is found. Then she at once begins to gnaw vigorously at the woody fibres, working excitedly with might and main until a little bundle has been separated, and the fragments of fibre have been gnawed and worked up into a kind of wood pulp. Grasping this precious burden with her jaws and front legs, she flies back, and disappears within the hole in the hedge bank.

Within the excavation in the hedge bank, she now clings to the roof with her second and third pairs of legs, while with the first pair, and the aid of her powerful jaws, she attaches the wood pulp she has brought with her to the ceiling of the chamber. There are now swift, repeated visits to the old weathered palings for fresh supplies of wood pulp, which are in turn worked up and attached to the first piece fixed to the roof of the chamber, until at last a small pendent pillar of wood pulp is formed. The Queen Wasp now proceeds to form three very shallow, cup-shaped cells at the end of the pillar, and, after depositing an egg in each, constructs a protecting wood-pulp roof over them. More cells are continually added, eggs deposited therein, and the wood-pulp roof extended over them.

In a short time the eggs that were deposited in the first three cells have hatched, and tiny hungry grubs have emerged. The little grubs, or larvæ, grow rapidly, and as they increase in size so the Queen Wasp adds more material to increase the depth of the cells, that the larvæ shall not fall out although suspended head downwards. The busy parent is now toiling all day long, enlarging the chamber by excavating the earth from the roof, sides, and floor, then going forth to seek further

Wonders of Insect Architecture.

supplies of wood pulp for the building of the nest, and bringing fresh food supplies for her hungry offspring. At last the first batch of larvæ attain their full size, cease to feed, and spin a silken cover over their cells. Beneath this silken coverlet they change to pupæ and undergo their final transformations, and the now perfect wasps gnaw their way out of the cells. As soon as the young wasps have gained sufficient strength they begin the labours of nest-building and feeding the larvæ; the Queen Wasp now has little else to do but deposit eggs in the cells as fast as they are built by the worker wasps, who are really sterile females, incapable of producing offspring, and very much smaller than the fertile queen.

Now the colony begins to rapidly increase in numbers, and the cells of the first comb become filled, and more accommodation is required. Using the junction point of these cells of the first tier as a foundation, the worker wasps form a series of pendent columns in exactly the same manner as that built by the queen, and by adding cells to each column they are eventually all united, and form a second tier at just sufficient distance below the first to permit the wasps to cross each other on the upper and lower tier without touching. In this second tier, as in the first, the mouths of the cells all open downwards and their bases are uppermost, so that the bases of the second tier form a floor on which the wasps can walk without disturbing the larvæ in the cells of the first tier above. In this way a third, fourth, and fifth tier are added, all exactly alike as regards the size of the cells in which the great multitude of worker wasps are reared.

How Animals Work.

The season has now far advanced, and the wasps, as if aware of the approach of autumn, begin to form tiers the cells of which are of much larger dimensions, and are destined to be the nurseries in which perfect male and female wasps will be reared. By the time these fully developed males and females have completed their transformations summer has practically passed, and they very shortly leave the nest, to which they will never return, for none of the males survive their brief wedlock for more than a few hours. A large proportion of the fertilized queens perish with the first frosts of autumn, only the comparatively few lucky surviving queens creeping into warm, sheltered nooks, where they will remain dormant in the profound sleep of hibernation throughout the winter, awakening with the return of spring, each to become the foundress of a new nest. As soon as the perfect males and females are reared, then the worker wasps, who have laboured so indefatigably throughout the summer in the construction of this wonderful nest and in the rearing of its teeming inhabitants, cease their toiling, and instead of continuing to feed and tend with unremitting care the remaining larvæ, seize upon them, drag them from the cells, bear them far afield, and there abandon them to a quick death by exposure, or perhaps to be pounced upon by some hungry bird. In this way during the first chill days of autumn the entire population desert the nest and perish.

The Wood or Bush Wasp is a little smaller than the Common Wasp, and instead of excavating a chamber in the soil, hangs its nest from the branches of some woodland tree or bush, or sometimes under the project-

Wonders of Insect Architecture.

ing roof of a farm building. The little round nest, often slightly pear-shaped, is a very beautiful structure, its outer covering or envelope being made up of a perfectly smooth gray paper, which is slightly shiny and flexible, and quite impervious to water, so that the larvæ within the nest are kept snug and dry, no matter how violent the summer showers. As in the case of the Common Wasp, it is the Queen-Mother Wood Wasp who, after her long winter sleep, comes forth and begins the building of the nest. She selects the site and forms the foundations of the nest, working up the wood pulp with her jaws, mixing it with saliva, and spreading and moulding it to the required shape. In the middle of the nest she forms a thick column, sustaining a single comb, which is generally composed of from eight to twelve cells. This work completed, she deposits an egg in each cell; and when the resulting larvæ have hatched and successfully passed through their transformations, they become her workers and nurses. These workers now enlarge the first comb by adding new cells around it. Then they set to work and construct a second comb, attaching it to the first by two or three pillars, and in this way a succession of combs which may total to six tiers will be constructed, the number depending on the increase of the population of the nest. The whole is covered with three paper envelopes placed one over the other, which are never attached to the combs, but form a perfect waterproof protection, with an opening at the base of the nest sufficiently large to permit the wasps to come and go with ease about their business.

A wasp having a long slender body, and the first

How Animals Work.

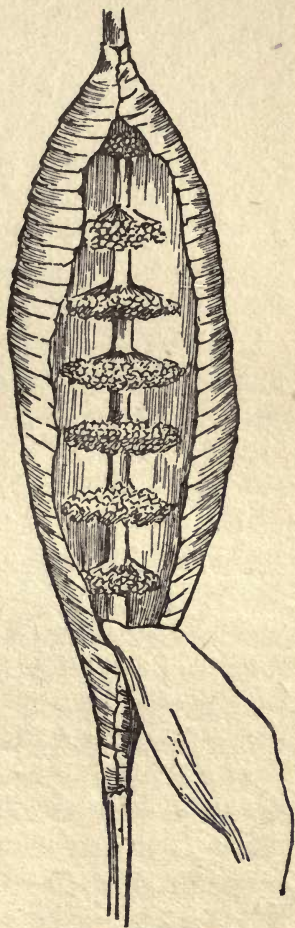
segment of the abdomen formed into a long pedicle or stalk, and called the *Polistes Gallica*, is an interesting little nest-builder frequenting open spaces and woods in France. In the spring-time it is a most interesting sight to watch the little wasp building her nest and feeding her offspring. This wasp is particularly fond of attaching her nest to the straight, narrow stems of the broom, which grows in the most convenient form for her particular method of building, and in such situations as she loves to frequent. Early in May the little mother *Polistes* thoroughly awakens from the torpor of her long winter sleep, and sets to work with great vigour and perseverance upon the construction of her nest. She collects fibres of bark from the neighbouring trees, and chews them up with her strong jaws until a perfectly homogeneous pulp is produced and converted into a strong gray paper. With this material mother *Polistes* forms a solid foundation for the nest, and a strong stalk, or peduncle, which has to maintain the comb. This comb is very small and never covered up with protecting outer envelopes, and is subsequently increased in size by the addition of new cells. These nests are always placed obliquely on the plant stem to which they are attached, so that the rain falls off them without entering the cells; while, as a further protection, the larvæ when about to change to the pupa stage close their cells by forming a silken cocoon.

The Armadillo Wasp, which is found in Guiana, builds a most remarkable nest, its ridged exterior having a fancied resemblance to the back of the animal from which the wasp takes its popular name. This wasp selects as its building site the straight and upright

Wonders of Insect Architecture.

branch of a tree which has no lateral twigs, and makes the branch the axis or central support of the nest. To the branch a series of combs, each composed of a limited number of cells, are firmly attached, each tier separated by an appreciable space. Over these combs, to which it is not attached, a very elaborate paper envelope is formed, and attached closely to the branch above and below the combs, with a small opening low down for the entry and exit of the wasps. The fibres of which this paper envelope is formed are arranged with wonderful regularity, and the envelope is tinted with longitudinal bands of different colour, while its surface is marked with transverse oval ridges, giving it a scalloped appearance.

The slim-bodied *Polybias* of tropical America are all remarkable builders. Some, like the *Polybia liliacea*, make a wonderful nest, nearly four feet in height and containing thousands of cells, which is attached to a branch of a tree and covered with a thick, rough envelope of almost cardboard texture. Others make the most tiny, frail, and beautifully formed habitations, about a quarter of an inch in length, on the under sur-



Nest of *Polybia*.

How Animals Work.

faces of the palm leaves. *Chartergus nidulans*, one of the so-called Pasteboard Wasps and a native of Brazil, makes a most beautiful covering to its nest of a polished white appearance, and so solid as to withstand the heavy tropical rains. So closely does the work of these insect paper-makers resemble that manufactured by the mechanical means employed by man, that the French naturalist Réaumur, on showing some of the material of which these nests are composed to a cardboard manufacturer, the expert in paper promptly declared it to be most likely the produce of a certain factory at Orleans.

Have you ever really carefully examined the combs in a beehive, or the honey-filled comb on the breakfast-table? It is well worth looking at closely, for it is one of the most wonderful, if not *the* most wonderful, of the structures built up by insects. For its purpose, the comb of the Hive Bee is absolutely perfect in every respect; and that is a statement which cannot be made concerning many structures. Our greatest mathematicians agree that the six-sided cell, with its base composed of three rhombs or diamonds, adopted by the Hive Bee, is the best possible shape for her requirements. As regards the materials for the construction of the comb, the bee does not need to collect them, but produces them from her own body, in the shape of thin sheets of beeswax—the very best material that could be chosen for the purpose. Indestructible to all the elements save heat, it can be rendered soft and pliable and worked up into plates only the one hundred and eightieth part of an inch in thickness—the normal thickness of each cell wall. A bad conductor of heat, beeswax is therefore a valuable building material, as it will conserve the heat

Wonders of Insect Architecture.

of the hive ; while apparently the only creature that will eat it is the larva of the Wax Moth, against whose depredations, however, a strong hive of bees will always hold their own.

The wax-secreting organs lie just under the segments of the abdomen of the bee, three on each side of the body ; and when the process of wax secretion is going on, the little whitish oblong scales of wax can be seen projecting from under the body segments. One of the joints of the hind leg of the worker bee is wonderfully modified so as to form a special instrument for the removal of the wax from the body segments. The wax is then transferred to the insect's jaws to be masticated, and, with the addition of saliva, worked up into a paste and materially increased in bulk. The resulting soft, pliable material is then applied to the construction of the comb.

The building of a new bee city is a serious undertaking, and many and complicated are the problems which confront its builders in the course of their labours. The way in which these difficulties are surmounted, and the perfection of result attained, fill one with admiration and wonder. In the city about to be built accommodation has to be provided for some twenty thousand or more individuals. Provision must be made for the adequate supply of nurseries, as something like ten thousand or twelve thousand baby bees may be requiring attention at one time. Then sufficient storerooms must be built in which to pack away enough food supplies to carry the community over the long six months of autumn and winter, when no supplies can be procured outside the hive. All this has to be planned within a limited space,

How Animals Work.

attention being given at the same time to perfect ventilation; and as the temperature in winter can only be kept up by the bodily warmth of the bees, the building materials and general construction must conserve and not dissipate the heat—factors of vital importance to the health and prosperity of the bee city. And for all the work of construction nothing but wax can be employed—precious material which must be used with the greatest economy; while the work must be performed in the shortest possible space of time, and with the minimum amount of labour consistent with perfect results.

In the construction of the comb the worker bee is confronted with the problem of producing a receptacle which will serve alike as a nursery and a storehouse for honey. The shape of the young bee larva being round and oblong, a cylindrical cell at once suggests itself as the most suitably shaped structure to build, for it would serve quite as well for a honey vat, or as a nursery. But thousands of these cylinders will be needed; and they must be packed as closely together as possible, so that there shall be no loss of warmth, and also to economize space. Now, no matter how closely you pack together round cells or tubs, there will be useless interstices left between them, which will require a large amount of wax to fill up. Obviously, then, the perfect cylinder is not the ideal form of receptacle it at first appears to be.

In problem number two the question arises how best to dispose the large number of receptacles, once their shape has been definitely decided upon, so as to effect the greatest saving in space and in building mate-

Wonders of Insect Architecture.

rials. They might be arranged tier upon tier, like the papery combs of the wasp, only mouth upwards, so that the honey could not run out. But such an arrangement has many disadvantages: it would necessitate the building of a substantial floor to support the weight of the cells when filled with honey; and, to prevent sagging of the floors during the heat of summer, they would have to be supported by pillars placed here and there, as may be seen in the wasp's nest—work that would use up much precious wax.

How does the worker bee solve these problems? The first she accomplishes by the one and only possible solution—namely, by adopting the hexagonal cell, with its base composed of three rhombs, as the shape of the receptacle that shall serve as nursery or storehouse as occasion shall require; while the second is accomplished by placing the cells back to back, so that one thin central, vertical sheet of wax serves to stop the ends of all the cells on each side. Moreover, the vertical comb is not built from below upwards, but from the top of the frame or from the roof downwards. First, a small block of wax is attached to the roof, and then on either side of this support the bees hollow out depressions which become the bases of the first cells. After this the work is extended downwards and sideways, the cell bases being multiplied as quickly as possible in all directions, with the result that there are a great number of half-finished cells in process of construction long before the walls of the first cells are completed, this rapid first extension of foundations permitting a greater number of bees to work on the formation of the cells. Close

How Animals Work.

inspection will also show that the cells are not being built end to end in line, but that each cell base on one side of the comb covers part of three cell bases on the other. Should we, with the help of a fine needle, perforate the three diamonds which form the triangular base of a single cell, and then turn over and examine the comb on the opposite side, we shall see that each hole enters a separate cell. By this arrangement the pyramidal bases on each side of the comb engage alternately like the teeth of a spring trap, and a considerable saving in total width of the comb is attained; while the faces of the pyramids are so contrived that each of them helps to close two cells. Moreover, by this arrangement the apex and three ribs of each pyramidal cell base form foundation lines for the cell walls on the other side of the comb, so that not only do all cell walls abut on an arch, but every cell base is strengthened throughout by a triple girdering; and in this way the amount of wax required for the building of the comb can be everywhere reduced to an absolute minimum. Indeed, this piece of comb, built by the unceasing labours of the worker bees from material secreted by their bodies, is one of the most wonderful and perfect examples of expert craftsmanship to be seen the whole world over.

CHAPTER VII.

WONDERS OF INSECT ARCHITECTURE: SOLITARY BUILDERS.

THE Bees and Wasps whose wonderful architectural powers we have so far considered all live in communities of varying size, and from this general habit are called Social Bees and Wasps. There are, however, a number of species which do not live in communities, but in which each individual builds its own nest. These Solitary Bees and Wasps are quite as clever artisans as their Social relations, and although the nests which they construct do not attain to such a size, they are wonderful examples of skill; while the habits of the little Solitary builders are in many instances most deeply interesting.

The Mason Bee is very common in some parts of France, and it was the great naturalist Réaumur who first drew attention to its wonderful skill as a builder in stone and cement. On the surface of a sun-baked stone wall numerous small, more or less dome or egg shaped lumps of mud may often be seen, looking as if some one had been throwing pellets of mud at the wall, to which they had become attached. Closer inspection will show them to be formed not of mud, but of a clever admixture of gravel and earth, which sticks

How Animals Work.

to the wall with the greatest tenacity, requiring the use of hammer and chisel to detach it. These oval masses have been carefully built up, with wonderful patience and art, by the little Solitary Mason Bee, who has worked upon them as both architect and labourer.

It is in May that the female Mason Bee begins her work. In the warm sunshine she may be seen most carefully and methodically exploring every inch of the surface of a stone wall. She will have nothing to do with stucco or plaster, so dear to the heart of the human jerry-builder, for she seems to be fully aware of its unstable character. Having selected what she considers a suitable site, she goes off to collect her building materials, flying off to some spot where a patch of sandy or gravelly soil is exposed. Here she begins scraping with her feet and working with her jaws until she has dislodged a few small stones and sand-grains of a certain size. These are mixed with earth, and a little saliya which she disgorges, working the whole up into a kind of mortar or cement to be used in building. This successfully accomplished, she firmly grasps the pellet and wings her way back to the wall, fastens it there, and then hurries back for more. Sufficient material collected, the little Mason now commences building operations, working at the cement until the walls of a tiny, somewhat oval-oblong cell begin to appear. She works with a perfect fury of enthusiasm and tireless energy, so that in one day of ceaseless labour the cell is constructed, and its inner walls carefully smoothed.

Now comes a change of work, for the completed cell has to be victualled, and for the time being the little

Wonders of Insect Architecture.

hodman-architect must become an equally expert caterer, wise in the collecting and blending of precious food-stuffs. Nothing daunted, away on joyous, swiftly vibrating wings she flies to the sunny meadows, all fragrant with grasses and flowers, there to collect honey and pollen. Flying rapidly from flower to flower, the little Mason's crop soon becomes distended with honey, and the lower surface of her body golden with pollen. Away back to the cell, which she enters head first, and for a moment we get a peep of her quivering body, which tells that the honey is being disgorged from her crop. Coming out of the cell, she turns round and re-enters it backwards, this curious operation being performed apparently that she may the better brush with her two hind legs the load of golden pollen off her body on to the regurgitated honey. This accomplished, she enters the cell again head first, to stir and properly mix together the honey and pollen into a sweet mass. Many visits have to be made to the meadows, but at last the cell is half filled with the honey paste, and victualling operations are completed. An egg is now deposited on the food mass, and the entrance to the cell closed in by a cover of fine, undiluted mortar. Given fine weather, the whole operation of cell-building, victualling, egg-laying, and closing of the entrance is completed in about two days. This, however, does not see the close of the labours of our little insect architect, for no sooner is the first cell completed and victualled than a second cell, backing on the first, is started, built up, and stored in the same way ; and so in succession a third, fourth, fifth, up to maybe eight or ten cells, all close together, are built, provisioned, an egg

How Animals Work.

deposited in each, and carefully sealed. Each cell is methodically completed before a second is attempted.

And now the little Mason Bee must begin her final labours, for although each cell is completed and sealed, its walls are not sufficiently thick to withstand rough weather. The burning heat of the midsummer sun would convert each cell into a miniature oven, while the rains of autumn and the frosts of winter would disintegrate its walls. So, when all the cells are completed, the little Mason sets to work to build a thick, substantial cover over the whole group—a cover which shall be practically a non-conductor of heat or cold, and impermeable to moisture, so that all is snug and dry within. Layer upon layer of cement is plastered on until a thick dome, about as big as half an orange, encloses the group of cells and hides them from view. No care is taken to smooth or decorate the outside of the dome, so that, but for its oval shape, the nest looks like a clod of mud. Nor is this rough, unfinished exterior unintentional, or a sign that the little Mason had grown careless as her labours reached their final completion, for that rugged exterior helps to hide the precious contents from the sight of many foes.

As the months slip by, what is happening beneath that plastered dome? From the single egg laid in each cell a tiny grub or larva comes forth, feasts upon the mass of honey paste provided for its sustenance, and when all is devoured spins for itself a silken lining to the walls of its chamber, a cocoon in which to pass through its final transformations. And now, their metamorphosis completed, the adult bees—reddish-coloured males and black females—are

Wonders of Insect Architecture.

ready to quit the nest. Yet how will they make their escape from their prison-like home, the walls of which are stout and hard as rock, and appear to have no doorway? Thoughtful mother Mason Bee has made provision, however, for the eventful day when the offspring she is destined never to behold shall have completed their transformations, and stand ready to emerge from the safe retreat upon the construction of which she lavished so much toil and care. When constructing the roof and general wall of the nest, the little Mason Bee left a narrow slit low down near each cell, a kind of door, hidden very carefully by rather soft sand or cement, through which the young perfect bees will be easily able to make their escape, breaking it down, and so making their way into the sunshine of the outer world.

When seeking for a suitable situation or building site, the little Mason Bee will, should she find one, use the ruins of a last year's nest for the foundations and walls of a new one. These old and more or less ruinous nests, containing vacant cells and the skins of the pupæ, very frequently remain attached to the wall or stone upon which they were built; and the Mason Bee, when exploring for a suitable building site, appears to keep a sharp lookout for them, for if she can discover one it will mean a considerable saving of time and labour. Should she succeed in her search, the little Mason at once enters into possession, and will fiercely contest her rights should another of her species dare venture to claim possession. She enters the ruins, and at once begins a thorough spring cleaning, removing the debris of the cocoons and the cast skins

How Animals Work.

of the larvæ and pupæ, and all unclean material that may have accumulated. Then the holes and weak places are all filled up and strengthened, until the old nest is converted into a perfect state of repair, and resembles in every respect that of the previous year.

Another closely related Mason Bee (*Chalicodoma sicula*) is far more sociable in its habits, and, according to that veteran authority Monsieur J. H. Fabre, "several thousand will establish themselves on the under surface of the tiles of a hovel or the edge of a roof. It is not a real society with common interests, dear to all, but merely a gathering where each works for herself and is not concerned with the rest. Every constructor builds as the fancy takes her, where and as she wills; only she must not interfere with her neighbour's work, or rough treatment will soon call her to order. This work goes on all through May. At length all the eggs are laid, and the bees, without any distinction as to what does or does not belong to them, all set to work on a common shelter of the colony—a thick bed of mortar—filling up spaces and covering all the cells. In the end the nests look like a large mass of dry mud, very irregular, arched, thickest in the middle, the primitive kernel of the establishment, thinnest at the edges, where there are fewest cells, and very variable in extent."

The Leaf-cutting Bees excavate holes in the ground, in rotten wood, or will take possession of any existing excavation that is suitable or can be adapted to suit their purpose. There is a Rose-leaf Cutting Bee which sinks a perpendicular shaft in tolerably solid earth to a depth of some inches, and then enlarges it into a horizontal gallery of considerable length. She then flies

Wonders of Insect Architecture.

away to the rose bushes, and begins to examine their foliage critically, finally selecting a nice, perfect leaf, upon which she settles and proceeds to cut out a large oblong piece with her mandibles. So perfectly is this done that one might easily imagine it had been done by a pair of scissors. Cutting rapidly, the bee soon detaches the piece of leaf, which, however, is not allowed to fall to the ground, but is held between the legs and jaws, whilst the wings vibrate strongly, and is at once carried off to the nest. Ten or twelve pieces of different shape will be cut off in this manner and transported to the nest, where the bee sets to work and folds them, one within the other, in the most expert fashion, so as to form them into a sort of thimble-shaped cone. She then visits the flower garden in search of honey and pollen, returning again and again, until she has gathered in sufficient to work up into a mass of honey paste, which she places at the bottom of the cell, and upon this she deposits a single egg. She now once more visits the rose bushes, and cuts from the leaves a series of very nearly perfect circles, which she uses to seal up the top of the cell. A second cell is constructed in the same manner, its base fitting against the top of the first, and thus a series of eight or ten cells is formed, stocked with honey paste, and an egg deposited in each. Then when the cell is completed, the little bee comes out and closes the perpendicular shaft with some of the earth she dug out in excavating it, working so carefully that no trace of the entrance can be seen.



Nest of
Leaf-cut-
ting Bee.

How Animals Work.

The Poppy Bee selects the petals of the common scarlet poppy to line her nest. First she digs perpendicular holes, selecting a dry, sandy soil for preference, and smooths and pounds their sides with her feet so as to make the walls firm and lasting. Then off she flies in search of poppies, and, selecting the youngest and freshest, cuts off pieces of the petals of the most beautiful flowers. She then flies back to the hole she has dug, and stuffs the strip of poppy petal into it. The delicate red tissue is crumpled in the process, but once inside the bee sets to work, and presses the petal against the sides of the hole, working away until every crease has been smoothed out. In this way the interior of the cell is lined with the vivid scarlet pieces of poppy petal. A mass of honey and pollen is then worked up and an egg placed on it. The free ends of the lining of the cell are folded in to prevent any sand falling upon the egg or the honey paste, and the entrance to the cell is obliterated.

The great violet-winged Carpenter Bee is a most interesting insect, and a very capable worker in wood, while the genus to which she belongs contains many of the largest and most powerful bees, and is very widely distributed in various parts of the world. When about to construct her nest the Carpenter Bee may be seen flying from tree to tree, carefully examining the boughs, and she will also investigate every wooden post and beam that may be in the neighbourhood in her search for a suitable site. What she is really seeking is a piece of dry, seasoned wood, that is not too hard for her jaws; for she never touches green living timber, though she will form her nest in all sorts of dry wood that may

Wonders of Insect Architecture.

happen to be at hand. A satisfactory site having been found, the Carpenter Bee at once sets to work, and gnaws away with her strong mandibles to excavate a cylindrical hole, some twelve inches or more in depth, and which ultimately gives access to three or four parallel galleries, in which she will form her broad cells. This piece of carpentry is by no means a light undertaking, and the bee may have to labour incessantly for several weeks ere she sees its completion satisfactorily accomplished. Small wonder, therefore, that she gladly welcomes the discovery of an old gallery in a tree, or a wooden post, or a beam already perforated by cylindrical holes, and will at once utilize such sites to meet her requirements. The work of excavation completed, the Carpenter Bee flies off, and collects honey and pollen for the usual honey paste to provision her cells, after the manner of the Mason and Leaf-cutting Bees. The honey mass accumulated and the egg deposited, the Carpenter Bee now proceeds to build up a partition wall to isolate the cell. This she does by mixing saliva from her jaws with the sawdust she has accumulated in the course of her work of excavating the gallery, working the sawdust up in this way into a thick pulp. More supplies of food are brought in, another egg deposited, and another separating partition of wood pulp formed, and this process is continued until about a dozen of these cells have been constructed, one above the other; then the entrance to the gallery is closed.

We have in Great Britain a very interesting little bee which makes its nest of wool or cotton, which it obtains from plants growing near at hand. This interesting little weaver is known as the Carder Bee, and is

How Animals Work.

referred to by good old Gilbert White, who says of it in his ever delightful *History of Selborne* : " There is a sort of wild bee frequenting the garden-campion for the sake of its tomentum, which probably it turns to some purpose in the business of nidification. It is very pleasant to see with what address it strips off the pubes, running from the top to the bottom of a branch, and shaving it bare with the dexterity of a hoop-shaver. When it has got a bundle almost as large as itself, it flies away, holding it secure between its chin and its forelegs." These Carder Bees do not appear to form burrows for themselves, but will utilize cavities in wood that have been formed by other insects, or take possession of the deserted nests of other bees. The Carder Bee having found a suitable receptacle, will line it with a most beautiful network of cotton or wool, and inside this she places a finer layer of the material, to which is added a sort of waterproof cement to prevent the honey mass stored by the bee for the use of its offspring from leaking out of the nest. One species of Carder Bee which forms its nest in hollow stems has been made the special study of Monsieur Fabre. He has observed that it will take the cotton for its nest from any suitable plant growing near at hand, not confining itself to any particular order of plants, or even to those peculiar to the south of France. " When it has brought a ball of cotton to the nest, the bee spreads out and arranges the material with its front legs and mandibles, and presses it down with its forehead on to the cotton previously deposited. In this way a tube of cotton is constructed inside the reed. When withdrawn, the tube proved to be composed of about ten distinct cells arranged

Wonders of Insect Architecture.

in linear fashion, and connected firmly together by means of the outer layer of cotton. The transverse divisions between the chambers are also formed of cotton, and each chamber is stored with a mixture of honey and pollen. The series of chambers does not extend quite to the end of the reed, and in the unoccupied space the insect accumulates small stores, little pieces of earth, fragments of wood or other similar small objects, so as to form a sort of barricade in the vestibule, and then closes the tube by a barrier of coarser cotton taken frequently from some other plant, the mullein by preference. This barricade would appear to be an ingenious attempt to keep out parasites ; but if so it is a failure, at any rate as against *Leucospis*, which insinuates its eggs through the sides, and frequently destroys to the last one the inhabitants of the fortress."

Besides the Solitary Bees just described, there are a vast number equally skilful in their methods of building and in their habits ; but limitations of space render it impossible to further refer to them, and we must devote the remainder of this chapter to a very brief description of the Solitary Wasps. In these remarkable insects we appear to reach the very apex of insect intelligence in the work of collecting and storing special food supplies for the young. They form a very large group of insects, to which a great deal of attention and careful observation has been paid ; and so curious and interesting are they in their habits, that it becomes difficult to make a selection of examples which shall do justice to the whole. It is, however, more in the different methods employed in the capture of prey—

How Animals Work.

which consists of spiders, flies, the larvæ of different insects, and even such large insects as the grasshoppers, used by these Solitary Wasps for victualling the cells in which they deposit their eggs—that these insects are remarkable, than in the character of the receptacles formed for the reception of the egg and store of food.

In Central France, during the summer months, one may frequently watch the labours of a little Solitary Wasp called *Pelopæus*, which is a very expert mason, and works in a most intelligent and persevering manner, building her nest in walls, in the corners of buildings and similar situations. *Pelopæus* is a slender little insect, and does not look at all fitted to carry heavy building materials; yet she is a most ardent little labourer, going to and fro in the hot sunshine between the spot where she collects her materials and the site she has selected for the nest. Very thoroughly the little *Pelopæus* will explore every inch of the surface of a likely wall, her slender antennæ and body quivering with excitement. Satisfied that the surface is suitable for the attachment of her cells, *Pelopæus* may pause for a moment to indulge in toilet operations, washing her face and stroking her antennæ and body with her slender legs. Then off she darts swiftly to a spot close at hand where a clayey soil is exposed to view. Here she works up small portions of the clay with her mandibles and carries them back to the wall for the construction of the nest.

With the clay so obtained she builds a hollow chamber, and this satisfactorily accomplished, she departs on a hunting expedition to collect food supplies. This is no peaceful journey to the flowering fields, but

Wonders of Insect Architecture.

the bold adventure of capturing a dangerous and well-armed prey ; for the little Pelopæus elects to provision her clay-built nest with spiders. Pelopæus is at once a bold and prudent huntress, and confident in the knowledge that in her strong sting she possesses a most deadly weapon, she fearlessly attacks the spiders, and seems to thoroughly enjoy the dangers of the fight ; for if she can but get in one lightning thrust of her sting, the victory is hers. Knowing full well the danger of her foe, Pelopæus approaches the web with caution, seeking suddenly to pounce upon and sting the spider before it can do anything ; and generally she is successful. Accidents will happen, however, and the best laid schemes of a Pelopæus may end in disaster, and the spider, prepared for the attack, but apparently resting quietly unconscious of the approach of danger, lures on the over-confident little wasp, who finds her movements suddenly paralyzed by a series of fine threads, in which the more she struggles the more hopelessly she becomes entangled. Then the spider rapidly swathes her foe in layers of silken web and calmly devours her. However, this fate does not often overtake the Pelopæus, and generally she will manage to bring one, two, three or more spiders back to the nest, the number depending upon the size of the individual spiders.

These are all carefully stowed away in the cell, an egg deposited close to them, and then more clay is collected, worked up, and the little chamber closed. Pelopæus has by no means finished her labours with the construction and victualling of one cell, but at once starts upon the construction of a second, which is built

How Animals Work.

on to the side of the first, and upon the same horizontal line. This second cell is provisioned and sealed up in the same way as the first, and then a third, fourth, fifth, and sometimes up to an eighth, are added. The external surface of the finished nest is marked by long depressions which correspond with the intervals between the cells; while the lower part of the nest is thinner than the rest, and when the larvæ have become full grown, changed to pupæ, and completed their transformations, the adult wasps bite their way out from this part, and leave open holes showing where they have made their escape.

Mr. Bates during his sojourn at Santarem and exploration of the Amazon had many opportunities of watching the habits of the Solitary Wasps of those regions, and gives the following account of an interesting little worker in clay called *Pelopæus fistularis*: "It collected the clay in little round pellets, which it carried off, after rolling them into a convenient shape, in its mandibles. It came straight to the pit with a loud hum, and on alighting lost not a moment in beginning its work—finishing the kneading of its little load in two or three minutes. The nest of this species is shaped like a pouch, two inches in length, and is attached to a branch or other projecting object. One of these restless artificers once began to build on the handle of a chest in the cabin of my canoe when we were stationary at a place for several days. It was so intent upon its work that it allowed me to inspect the movements of its mouth with a lens whilst it was laying on the mortar. Every fresh pellet was brought in with a triumphant song, which changed to a cheerful busy

Wonders of Insect Architecture.

hum when it alighted and began to work. The little ball of moist clay was laid on the edge of the cell, and then spread out around the circular rim by means of the lower lip guided by the mandibles. The insect placed itself astride over the rim to work, and on finishing each addition to the structure, took a turn round, patting the sides with its feet inside and out before flying off to gather a fresh pellet. It worked only in sunny weather, and the previous layer was sometimes not quite dry when the new coating was added. The whole structure takes about a week to complete. On opening closed nests of this species, which are common in the neighbourhood of Mahicā, I always found them to be stocked with small spiders in the usual half-dead state to which the mother wasps reduce the insects which are to serve as food for their progeny." Mr. Bates also describes another Solitary Wasp which makes with clay "a neat little nest shaped like a carafe, building rows of them together in the corners of the verandas."

Another interesting little Solitary Wasp that builds with clay is called *Eumenes*. The nest, or rather cell (for she does not join the cells together like the *Pelopæus*), which *Eumenes* constructs with clay, is a small round, vase-shaped earthenware vessel, in the walls of which small stones are embedded to give it greater strength. The cell once formed, *Eumenes* sets about the work of provisioning it, using for the purpose small caterpillars to the number of fourteen or sixteen for each cell. Whether these caterpillars are stung or not does not appear to be quite certain; but if so, the caterpillars are not deprived of all movement, for they appear still

How Animals Work.

to possess the power of moving their jaws and the hind part of the body. Now if Eumenes placed her delicate egg in the midst of these caterpillars, it would probably suffer destruction. To prevent this happening, she suspends it by a delicate thread from the dome-shaped covering of the nest, so that it hangs above the mass of caterpillars. On hatching, the young larva does not descend, but still makes use of the egg-shell as its habitation, hanging down from this vantage point to feed upon the caterpillars below. As the egg-shell splits up to a sort of ribbon, thus adding to the length of the suspensory thread, the larva is able to reach down and devour a number of caterpillars before it is necessary for it to descend to the floor of the cell to get at those stored beyond reach from the thread, and by that time it has increased sufficiently in size and strength to take no harm from any movements of the few remaining victims.

Ammophila is a genus of Solitary Wasps having a very wide distribution, and its species make vertical tunnels in the ground—in fact, they may be said to be expert miners, excavating their miniature shafts, which generally terminate in an oval chamber, with considerable skill and dispatch, and victualling them with caterpillars, which they sting in such a way as to completely paralyze. Monsieur Fabre, in France, has paid special attention to their interesting habits, and the American species have been ably watched and described by Professor Peckham and his wife, from whose charming writings the following account has been compiled. For the nest, “the spot chosen is in firm soil, sometimes in open ground, but much more frequently under

Wonders of Insect Architecture.

the leaves of some plant. The plan is a simple one. A tunnel of about an inch in length leads to the pocket in which the caterpillars are stored. There is no hardening of the walls in any part. The work is done with the mandibles and the first legs. When it has proceeded so far that the wasp is partly hidden, she begins to carry the earth away from the nest. In doing this she backs up to the edge of the opening, and, flying a little way, gives a sort of flick which throws the pellet that she carries in her mandibles to a distance. She then alights where she is and pauses a moment before she runs back to the hole, or, in some cases, darts back on the wing. *Ammophila* having made her excavation, ran off, and after some search returned with a good-sized lump of earth. This she laid over the opening, which was not completely hidden. She then flew to the bean patch close by, but after ten minutes she came back and looked at her nest. It was so neatly covered as to be almost indistinguishable, but to this fastidious little creature something seemed lacking. She pulled away the cover, carried out three or four loads, and then began to search for another piece for closing. After a time she came hurrying back with a lump of earth, but when close to the nest she concluded that it would not do, dropped it, and ran off in another direction. Presently she found one that fitted into the hole exactly, and after placing it she brought a much smaller piece which she put above and to one side. She then stood back and surveyed the whole, and it seemed to us that we could read pride and satisfaction in her mien. She then flew away, and we supposed that that stage of the work was com-

How Animals Work.

pleted. Upon coming back two hours later, however, we found that she had been trying some new improvements, as a number of little pellets had been piled up over the nest."

After much watching and many disappointments the Peckhams were at last rewarded in seeing the *Ammophila* capture her prey. "The wasp attacked at once, but was rudely repulsed, the caterpillar rolling and unrolling itself rapidly and with most violent contortions of the whole body. Again and again its adversary descended, but failed to gain a hold. The caterpillar, in its struggles, flung itself here and there over the ground, and had there been any grass or other covering near by it might have reached a place of partial safety; but there was no shelter within reach, and at the fifth attack the wasp succeeded in alighting over it, near the anterior end, and in grasping its body firmly in her mandibles. Standing high on her long legs and disregarding the struggles of her victim, she lifted it from the ground, curved the end of her abdomen under its body, and darted her sting between the third and fourth segments. From this instant there was a complete cessation of movement on the part of the unfortunate caterpillar. For some moments the wasp remained motionless, and then, withdrawing her sting, she plunged it successively between the third and the second, and between the second and first segments. The caterpillar was now left lying on the ground. For a moment the wasp circled above it, and then, descending, seized it again, farther back this time, and with great deliberation and nicety of action gave it four more stings, beginning between the ninth

Wonders of Insect Architecture.

and tenth segments and progressing backwards." Having thus captured her prey, the *Ammophila* flies off with it to the nest. On arriving there she at once proceeds to remove the pellets of earth with which she had so closely masked the entrance, and then picking up the caterpillar brings it to the mouth of the burrow and lays it down. Then, backing in herself, she seizes it in her mandibles and drags it down out of sight.

The nest provisioned, and the egg deposited upon the inanimate form of the caterpillar, *Ammophila* now proceeds to close the nest and to most carefully obliterate all traces of the entrance. "In filling up her nest she put her head down into it and bit away the loose earth from the sides, letting it fall to the bottom of the burrow, and then, after a quantity had accumulated, jammed it down with her head. Earth was then brought from the outside and pressed in, and then more was bitten from the sides. When at last the filling was level with the ground, she brought a quantity of fine grains of dirt to the spot, and picking up a small pebble in her mandibles, used it as a hammer in pounding them down with rapid strokes, thus making this spot as hard and firm as the surrounding surface. Before we could recover from our astonishment at this performance she had dropped her stone and was bringing more earth. Once more the whole process was repeated, and then the little creature, all unconscious of the commotion she had aroused in our minds, gave one final, comprehensive glance around and flew away."

A pretty little Solitary Wasp that may sometimes be seen in large numbers flitting about the face of a

How Animals Work.

sand-bank that is exposed to the full rays of the sun is the *Odynerus*. It is a skilful little miner and mason, for it drives a little shaft into the sand-bank, and out of the material obtained in the process of excavation forms a fragile tube which projects beyond the entrance to the shaft. Scraping away at the face of the



Nest of Solitary Wasp
(*Odynerus*).

sand-bank, the little *Odynerus* soon collects sufficient grains of sand to work up into a small pellet, which is then placed on the edge of the excavation she has just started to make. Working vigorously in the hot June sunshine, she digs away with untiring zeal, pellet after pellet being formed and placed in position, so that as the shaft she is digging deepens the little cylinder projects further outward, at first perpendicularly to the surface on which its foundations rest, but later, as it increases in length, curving

over at what sometimes looks like a dangerous angle. The object of this curious leaning tower appears to be the masking of the entrance to the cell, and to discourage the investigations of certain unwelcome insect visitors who might desire to appropriate the chamber or deposit their eggs therein. The shaft having been sunk to a sufficient depth and the outside cylinder completed,

Wonders of Insect Architecture.

Odynerus departs in search of the helpless larvæ with which she victuals the cell. Backwards and forwards she flies, until she has collected perhaps ten or a dozen larvæ and stored them safely away at the bottom of the shaft; then, depositing an egg in the chamber, she comes forth and at once proceeds to block up the entrance. This she accomplishes by pulling down the masking tower and stuffing the pellets into the mouth of the shaft, finally bringing more sand grains and scraping all round the edges of the opening, until every external trace of it is removed.

CHAPTER VIII.

ANTS AND TERMITES.

THE Ants are indeed "a little people wondrous wise," and no one can watch their rapid, alert movements, their tireless energy, and equanimity in surmounting the most disheartening problems and difficulties, without becoming filled with admiration and wonder.

Any one who has, in the course of a summer ramble, passed through the sunny margin of a pine wood will probably be familiar with the outward appearance of the dome-shaped nests of the great Wood Ant (*Formica rufa*), the largest of our British species. According to the numerical strength of the colony and the season of the year, so the height of the dome will vary from a few inches to over two feet, while the circumference of the base will vary in proportion. The Wood Ant is an expert miner as well as a builder, for the first duty of the dome of the nest is to form a shelter to keep out the rain from the nurseries; and should we clear away the great heap of material which the ants have collected in its construction, we should find the openings to galleries or shafts driven down to a considerable depth, and leading to chambers set aside for special purposes.

Ants and Termites.

On a warm sunny morning in summer the surface of the nest will present a scene of great animation, the Wood Ants swarming all over its surface and hurrying hither and thither about their various duties. At first the busy scene may appear to be more or less an aimless hurrying to and fro, destitute of reason or useful purpose; but closer observation, without disturbing or alarming the busy little creatures, will prove this not to be the case. Each individual of the swarming multitude is engaged upon its own special duties, carrying out in its own characteristic manner the task it has to perform.

Should we time our visit at a fairly early hour of the morning, we shall find that a large number of the ants are busily engaged in removing the materials with which the previous afternoon they had closed all the entrances to the nest. One by one the slender pine needles, the tiny twigs, and fragments of leaves are dragged aside, until every doorway stands wide, permitting the unimpeded exit and entry of the hurrying workers. Now small bands of ants may be seen issuing from the nest and marching off into the pine wood, some in search of provisions, others to gather fresh supplies of building materials wherewith to increase the size of the dome and to strengthen it. Anon these ants return struggling valiantly under the weight of their burdens, hauling, pulling with might and main, displaying the most extraordinary agility and a muscular strength that seems out of all proportion to their diminutive size, making light of burdens many times their own bulk and weight. Some of these labourers will carry the piece of twig, leaf, or other building material

How Animals Work.

right up on to the nest, and place it in that position which seems to them best ; but others, directly they reach the confines of the nest, will drop their burden and hastily depart back to the woods in search of more. As fast as material is brought to the nest it is distributed, either being placed in position on the outside of the nest, or carried within to be built into the walls of the galleries and chambers that are situated within the dome ; for this edifice is by no means an absolutely solid mass of material, but contains many apartments and connecting passages, the former being used as day nurseries for the larvæ and pupæ, while the galleries lead to the exits, or downwards to the principal chambers excavated beneath the surface of the ground. As the ants drive their shafts downwards into the ground, the soil removed in the operation is not thrown away, but as it is brought to the surface is mixed with the pine needles and pieces of twig, helping to bind them together, and so give greater firmness and stability to the dome-shaped upper portion.

The chambers beneath the surface of the ground are not all excavated at the same level, but at various depths, so that, could we cut a perfect vertical section which would show the interior of the nest, we should see that the chambers were arranged on floors, rising from the basement, floor upon floor, in just the same manner as in a human habitation. By keeping the ants under constant observation we are able to learn the reason for this arrangement, and to discover how the eggs are all stored in special chambers, and how the larvæ are all sorted out according to age and size, so that each nursery only contains larvæ of a given age

Ants and Termites.

and size, or is devoted to the smooth, white, oval cocoons containing the pupæ, and which are popularly though erroneously called "ants' eggs." Again, according to the time of day, temperature, and climatic conditions prevailing outside the nest, so the larvæ will be found collected in the chambers on the different floors: the warmer the day, the nearer the roof of the dome; the lower the temperature, the deeper down in the subterranean chambers of the nest will they be found.

As the long, hot summer afternoon draws to a close, those ants who have been abroad all day may be seen trooping back to the nest. Some at once disappear within, while others stay to assist the workers who have been adding to the outside structure of the nest. Watching closely, we shall be able to see that constructive operations have ceased for the day, and that the busy little insects are now engaged upon a different duty: they are dragging the twigs and pine needles into position in front of the openings, and thus closing the doorways and making all snug and safe for the night. By the time night has drawn a pall of darkness over the pine woods every entrance has been closed, and only a few solitary ants lurk under leaves and similar shelters, playing the part of night watchmen, while the rest of the community are safe within the nest.

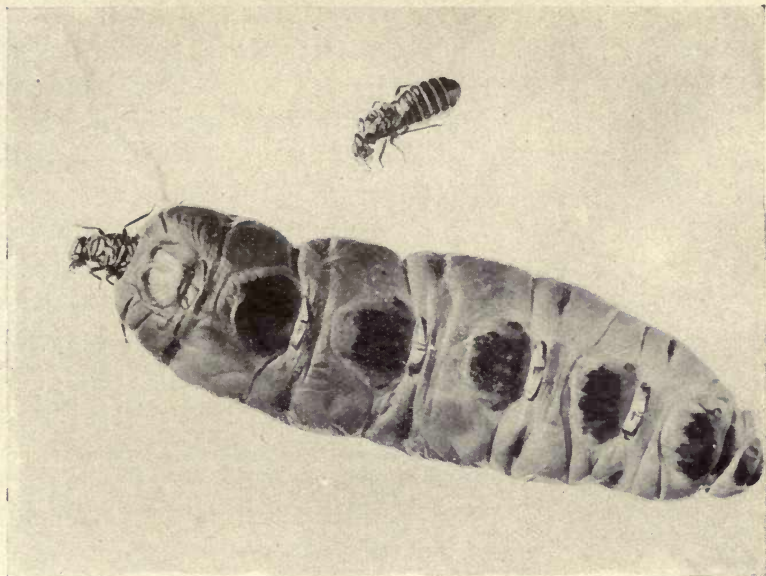
To those ants who build their nests entirely of earth the naturalist Hüber applied the title of Mason Ants. To the study of their habits and methods of building he devoted a great deal of time and attention, and left a very interesting and accurate description. "The earth of which their nests are composed," wrote Hüber,

How Animals Work.

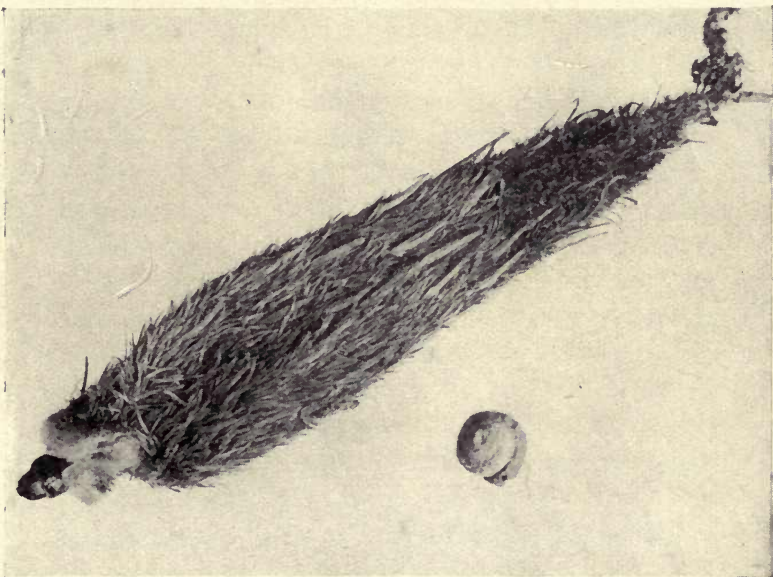
“ is more or less compact. That employed by ants of a certain size, such as the black and mining ants, appears to be less carefully chosen and forms a paste less fine than that of which the brown, microscopic, and yellow ants form their abode. It is, however, adapted to their capacities, to their needs, and to the nature of the edifice they intend to build. Thus the hillock raised by the black ants always has thick walls formed of coarse, lumpy earth, well-marked stories, and large chambers with vaulted ceilings resting upon solid pillars; we never find roads or galleries properly so called, but large cavities and extensive embankments of earth. We further notice that the little architects have preserved a certain proportion between the widely arched ceilings and the pillars which are to support them.”

Of the little brown ant, whose body only measures one-eighth of an inch in length, Hüber gives the following interesting description : “ This ant, one of the most industrious of its tribe, forms its nest in stories rather less than half an inch in height. The partitions are not more than one-twenty-fifth of an inch in thickness, and the substance of which they are composed is so finely grained that the surface of the inner walls appears quite smooth and unbroken. These stories are not horizontal; they follow the slope of the ant-hill, so that each curves over all those which lie below it, down to the ground floor, which communicates with the subterranean lodges. They are not always, however, arranged with the same regularity, for ants do not follow an invariable plan; it appears, on the contrary, that nature has allowed them a certain amount of freedom in this matter, and that they can vary their method

PLATE VIII.

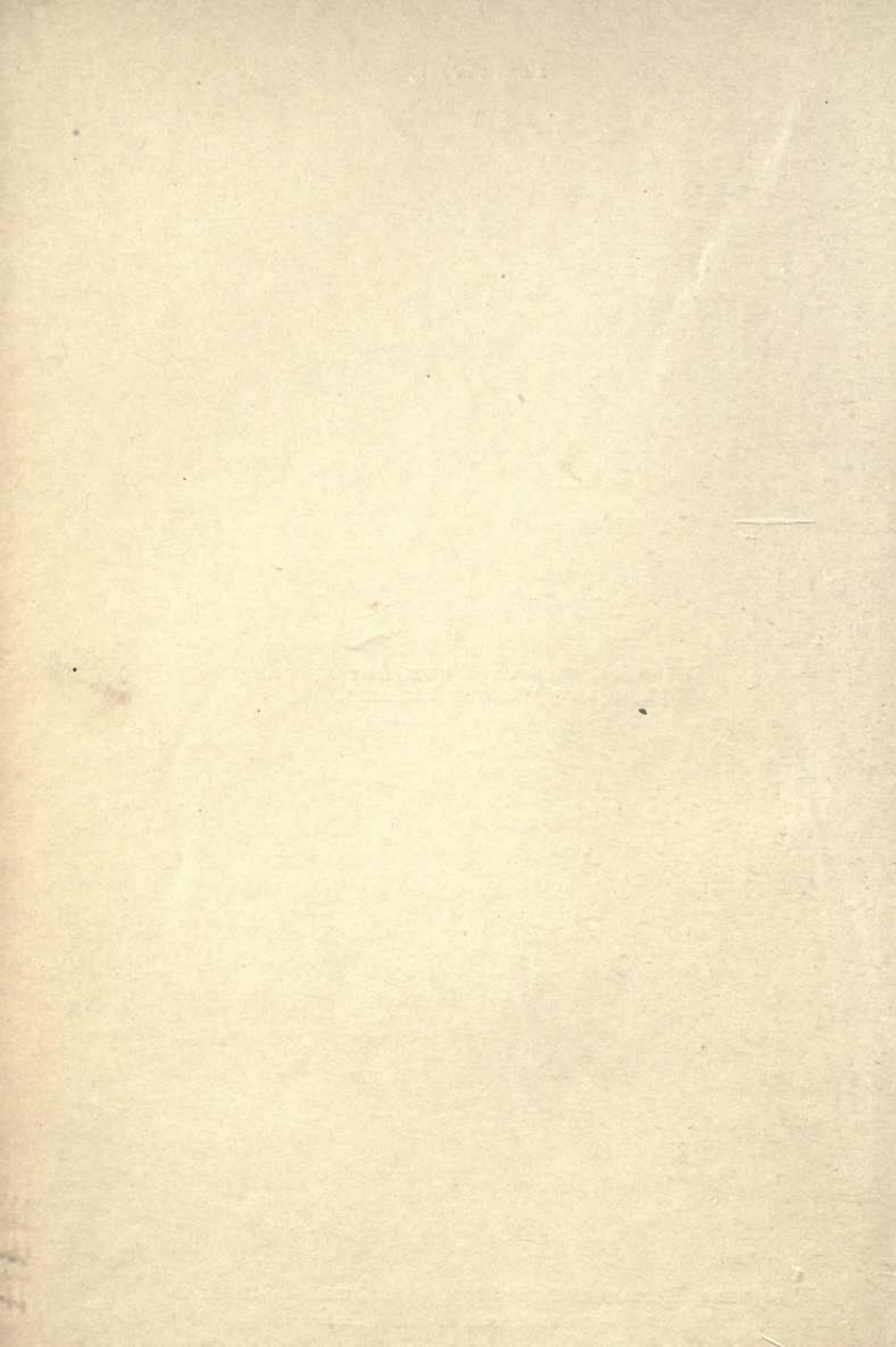


A QUEEN TERMITE OR WHITE ANT AND AN
ORDINARY WORKER TERMITE.



TWO VERY REMARKABLE PSYCHE CATERPILLAR GARMENTS.

One is shaped like a small snail's shell, while the larger one has a soft downy lining.



Ants and Termites.

at will, according to circumstances. But however fantastical their habitations may appear, we always observe that they have been built in concentric circles. On examining each story separately, we see a number of carefully formed cavities or halls, lodges of narrower dimensions, and long galleries which serve for general communication. The arched ceilings covering the most spacious places are supported either by little columns, slender walls, or regular buttresses. We further notice chambers that have but one entrance, communicating with the lower story, and large open spaces serving as a kind of crossing or junction in which all streets terminate. The ant-hill contains sometimes more than twenty stories in its upper portion, and at least as many under the surface of the ground—an arrangement which must enable the ants to regulate the heat to a nicety and with the greatest ease."

Unlike the Wood Ants, which rejoice in the warm sunlight, these smaller Mason Ants appear to shrink from it, only coming out on to the surface of the nest in the cool of the late afternoon and evening. Hüber also observed that these ants appeared greatly to appreciate a moist condition of the atmosphere, and actually to become actively engaged in building operations outside the nest during showery weather. "As soon as it began to rain they left their subterranean residence in great numbers, re-entered it almost immediately, and then returned bearing in their jaws pellets of earth, which they deposited on the roof of their nest. At first I could not imagine what this was intended for, but I soon saw little walls start up on all sides with spaces left between them, while in several places columns

How Animals Work.

ranged at regular distances announced halls, lodges, and passages which the ants proposed to construct : it was, in short, the laying out of a new story. Each ant, then, carried between its jaws the pellet of earth it had formed by scraping the bottom of its dwelling with the end of its mandibles. This little mass of earth, being made of particles only just collected together, could readily be moulded just as the ants wished ; and when they had put it into the position it was intended for, they divided it and pressed upon it with their jaws so as to fill up the smallest crannies of their wall. Their antennæ followed every movement, touching each pellet of earth ; and as soon as a particle had been placed in position the whole mass was made more compact by being lightly pressed by the forefeet. After tracing out the plan of their masonry by laying here and there foundations for the pillars and partitions they wished to erect, the insects raised them higher by adding fresh materials. It often happened that two little walls, which were to form a gallery, were raised opposite one another, a little distance apart. When they had reached a height of rather less than half an inch, the ants busied themselves in covering in the space left between them by a vaulted ceiling. After a while they ceased to work upwards, as if they considered the walls high enough ; they then placed particles of moistened earth against the interior and upper part of each wall, almost at right angles to it, thus forming a ledge which would, as it extended, join that coming from the opposite side. These ledges were about one-twenty-fifth of an inch in thickness, and the breadth of the galleries was usually about a quarter of an inch.

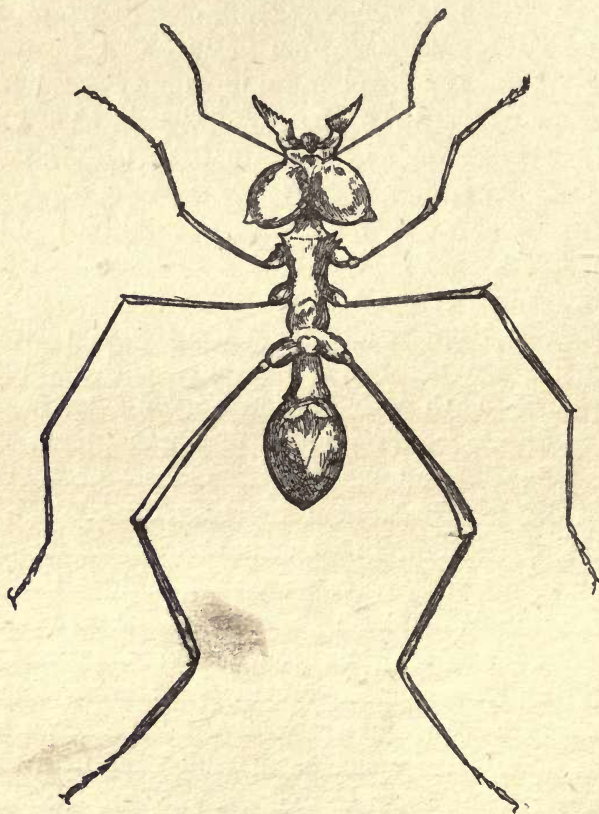
Ants and Termites.

In one part several upright partitions formed the scaffolding of a lodge which communicated with a number of corridors by openings in the masonry ; in another place there was a regularly formed hall, with numerous pillars sustaining its vaulted ceiling. Farther on it was possible to recognize the plan of one of those squares of which we have spoken before, in which several avenues terminate, and these were the most spacious parts of the ant-hill ; yet the work of constructing a ceiling to cover them in did not appear to cause the labourers any embarrassment, even though the spaces were often two inches or more in breadth. The first foundations of such a ceiling were laid in the angles formed by the upper part of the different walls, and from the top of each pillar, as from so many centres, a horizontal and slightly convex layer of earth was carried forward to meet the several portions coming from different points of the large public thoroughfare. The parcels of moistened earth, which are only held together by contact, seem to require a fall of rain to cement them more closely, and to varnish over, as it were, the ceilings they compose and the walls and galleries which are not yet covered in. Then all unevenness of the masonry is removed, and the upper part of the stories, composed of so many separate parts brought together, presents a united layer of compact earth which requires nothing but the heat of the sun to make it perfectly solid. The busy crowd of masons arriving from all parts with the load of concrete they wish to add to the building, the order they observe in their operations, the prevailing harmony, and the eagerness with which they avail themselves of the rain to increase the height of their

How Animals Work,

dwelling, present a most interesting spectacle to one who is a lover of nature."

The forests of tropical South America abound with numerous species of ants, many of which are extremely



Parasol Ant.

interesting in their habits and powers of construction. During a visit to that wonderful country, and while making a brief stay at Rio de Janeiro, I had an opportunity of watching some of the remarkable leaf-cutting

Ants and Termites.

or Saüba Ants, popularly called "Parasol" Ants. These ants are a great pest to the planters, as they march out of the virgin forest in countless swarms and, entering the plantations, wreak havoc amongst the cultivated trees, from which they will strip every vestige of foliage. I well remember, on my informing my host of my hope that during my short stay an opportunity might present itself for me to see the Saüba Ants in their native forests, the half-sad, half-whimsical expression that passed over his face as he assured me that on the morrow I should watch them the whole day long if I so desired. "Alas! Señor, like the poor, the Saübas are always with us. You have told us how we may rid ourselves of the malaria-transmitting mosquito; would to Heaven you could rid us of the Saüba Ants!" Later on I found that mine host had indeed good reason to complain of the depredations of these ants, which had denuded a large number of recently planted fruit trees of their foliage. Standing near one of the doomed trees, one became conscious, in the silence of the noontide heat, of a faint, snicking, rustling sound issuing from the tree—the sound of the countless worker Saüba Ants, all busily engaged with their sharp, strong jaws in cutting nearly circular fragments from the leaves. These circular pieces of leaf varied slightly in size, from about the diameter of a threepenny piece to that of a sixpence. As fast as the circles were cut out they were either let fall to the ground, where they were pounced upon and carried off to the nest, or the worker who had cut the piece of leaf off would seize it in her jaws, holding it upright, and at once descend the trunk of the tree and join the ranks of her friends, each carry-

How Animals Work:

ing its leafy burden, returning to the nest. These returning armies presented the most extraordinary appearance, winding along a well-marked path leading into the forest where the nest was situated, all hurrying along, each individual carrying aloft a piece of leaf which partly obscured the insect from view, and gave to the mass the appearance of a hurrying green rivulet or a green serpent.

On arriving at the nest a large proportion of the Saüba Ants deposited their leafy burdens, and at once returned to the tree for more, while others might be seen to enter the nest still grasping their burdens. An army of ants were busily working on top of the nest, placing the pieces of leaf in position, and covering them with layers of grains of earth so as to form a sort of thatch to protect the interior of the nest from rains. But this was not the only use which the Saübas were making of the fresh green foliage they were cutting from the tree. Those ants which brought their leaves within the nest were immediately relieved of their burdens by small worker ants, who carried the fragments into special underground chambers, and then cut them into smaller pieces, which were then carefully licked over, worked up into pellets of pulp, and massed together so as to form a regular heap or bed, destined in the course of a few days to become penetrated and covered with the whitish mycelial threads of a fungus upon which the ants are said to feed. This fungus the ants cultivate in the most skilful manner, keeping it clear of mouldiness, and making it produce a modified form of growth in the shape of small white masses, which form the chief food of the colony. The

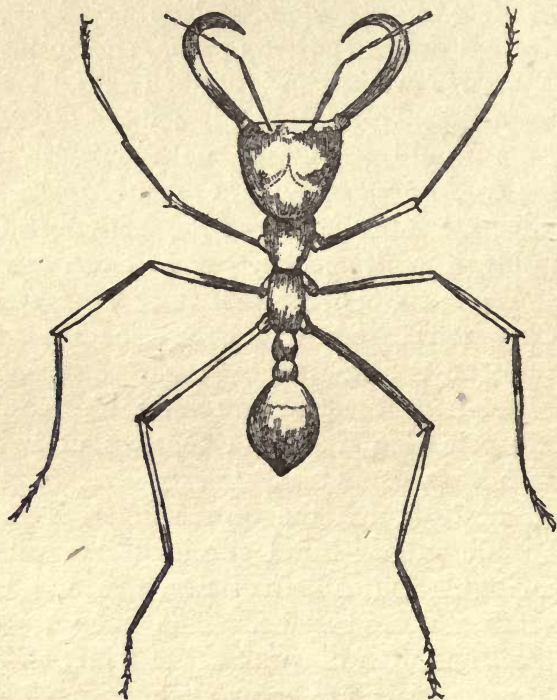
Ants and Termites.

Saüba Ants are a truly wonderful race; for they are not only expert builders and excavators, but are equally skilled in the knowledge of intensive culture.

The late Mr. H. W. Bates, who spent so many years investigating the teeming insect and animal life of the Amazons, had unique opportunities of observing the habits of the different species of ants, and in his charming book on his wanderings and adventures he gives many graphic descriptions of these insects. While the Saüba Ants would appear to be vegetarian in their habits, the true Foraging Ants, or Ecitons, the Tauocas of the Indians, are carnivorous ants, fearless and aggressive, hunting in vast armies, exciting terror wherever they go. While some of these Ecitons have their visual organs fully developed, one can trace step by step through different species the gradual atrophy of the eye, until both socket and eye have disappeared. It is interesting to find that with the loss of sight these insects take to a subterranean existence. Connecting those Ecitons in which the organs of sight are developed with the utterly blind species "is a very stout-limbed Eciton," writes Mr. Bates, "whose eyes are sunk in rather deep sockets. This ant goes on foraging expeditions like the rest of its tribe, and attacks even the nests of other stinging species (*Myrmica*); but it avoids the light, always moving in concealment under leaves and fallen branches. When its columns have to cross a cleared space, the ants construct a temporary covered way with granules of earth, arched over, and holding together mechanically; under this the procession passes in secret, the indefatigable creatures repairing their arcade as fast as breaches are made in

How Animals Work.

it. Next in order comes the *Eciton vastator*, which has no eyes, although the collapsed sockets are plainly visible ; and lastly the *Eciton erraticum*, in which both sockets and eyes have disappeared, leaving only a faint ring to mark the place where they are usually situated.



Eciton Ant.

The armies of *Eciton vastator* and *Eciton erraticum* move, as far as I could learn, wholly under covered roads, the ants constructing them gradually but rapidly as they advance. The column of foragers pushes forward step by step, under the protection of these covered passages, through the thickets, and on reaching a rotting log or

Ants and Termites.

other promising hunting-ground, pour into the crevices in search of booty. I have traced their arcades occasionally for a distance of one or two hundred yards; the grains of earth are taken from the soil over which the column is passing, and are fitted together without cement. It is this last-mentioned feature that distinguishes them from the similar covered roads made by Termites, who use their glutinous saliva to cement the grains together. The blind Ecitons, working in numbers, build up simultaneously the sides of their convex arcades, and contrive in a surprising manner to approximate them and fit in the keystones without letting the loose, uncemented structure fall to pieces."

Ants are not only expert miners, builders, and agriculturists, but some are great warriors and slave-makers. It would not be within the scope of the present work to go into all the curious habits of these warlike races, for we are considering the ants as master-builders rather than as victorious soldiers; but no account of the labours of these most deeply interesting insects would be complete without some reference to their tribal wars, and therefore the following instance of a successful raid, as witnessed and described by Hüber, may serve as an example. "As I was walking in the environs of Geneva," writes Hüber, "between four and five in the afternoon, I saw at my feet a legion of largish russet ants crossing the road. They were marching in a body with rapidity; their troop occupied a space of from eight to ten feet long by three or four inches wide. In a few minutes they had entirely evacuated the road; they penetrated through a very thick hedge, and went into a meadow, whither I followed them. They wound

How Animals Work.

their way along the turf without straying, and their column remained always continuous, in spite of the obstacles which they had to surmount. Very soon they arrived near a nest of ashy-black ants, the dome of which rose among the grass at twenty paces from the hedge. A few ants of this species were at the door of their habitation. As soon as they descried the army which was approaching, they threw themselves on those which were at the head of the cohort. The alarm spread at the same instant in the interior of the nest, and their companions rushed out in crowds from all the subterranean passages. The russet ants, the body of whose army was only two paces distant, hastened to arrive at the foot of the nest ; the whole troop precipitated itself forward at the same time, and knocked the ashy-black ants head over heels, who, after a short but very smart combat, retired to the extremity of the habitation. The russet ants clambered up the sides of the hillock, flocked to the summit, and introduced themselves in great numbers into the first avenues. Other groups worked with their teeth, making a lateral aperture. In this they succeeded, and the rest of the army penetrated through the breach into the besieged city. They did not make a long stay there ; in three or four minutes the russet ants came out again in haste by the same adits, carrying each one in its mouth a pupa or a larva belonging to the conquered. They again took exactly the same road by which they had come, and followed each other in a straggling manner ; their line was easily to be distinguished on the grass by the appearance which this multitude of white cocoons and larvæ, carried by as many russet-coloured ants,

Ants and Termites.

presented. They passed through the hedge a second time, crossed the road, and then steered their course into a field of ripe wheat, whither, I regret to say, I was unable to follow them."

Returning to the pillaged nest, Hüber saw some of its ashy-black inhabitants return to their home carrying the few larvæ they had succeeded in saving from the clutches of their victorious foes. Later on he discovered the nest in the wheatfield, and found there many of the ashy-black ants that had been carried in their larval and pupal stage, had completed their transformations, and were living apparently on perfectly good terms with their captors.

Greatest of all builders of covered ways are the so-called White Ants—the Termites, to give them their proper name—which are not related to the true ants at all, but belong to the Neuroptera, an order of insects under which are grouped the dragon-flies, may-flies, lace-wings, and ant-lions. The Termites never willingly expose themselves to view, and you may live for many months in a country swarming with them, and be perfectly familiar with the appearance of their great nests, and yet never set eyes upon a single Termite. They are far from pleasant-looking insects; but their fat, brownish-white, soft bodies are most tempting objects to all sorts of insect-eating creatures, and that is one good reason for their living and working beneath the soil, out of sight of all prying, hungry eyes. Throughout the Tropics the Termites are a great pest, for, living almost exclusively on wood, they will tunnel upwards from the ground into the beams and rafters of a house, giving no external evidence of their presence, working

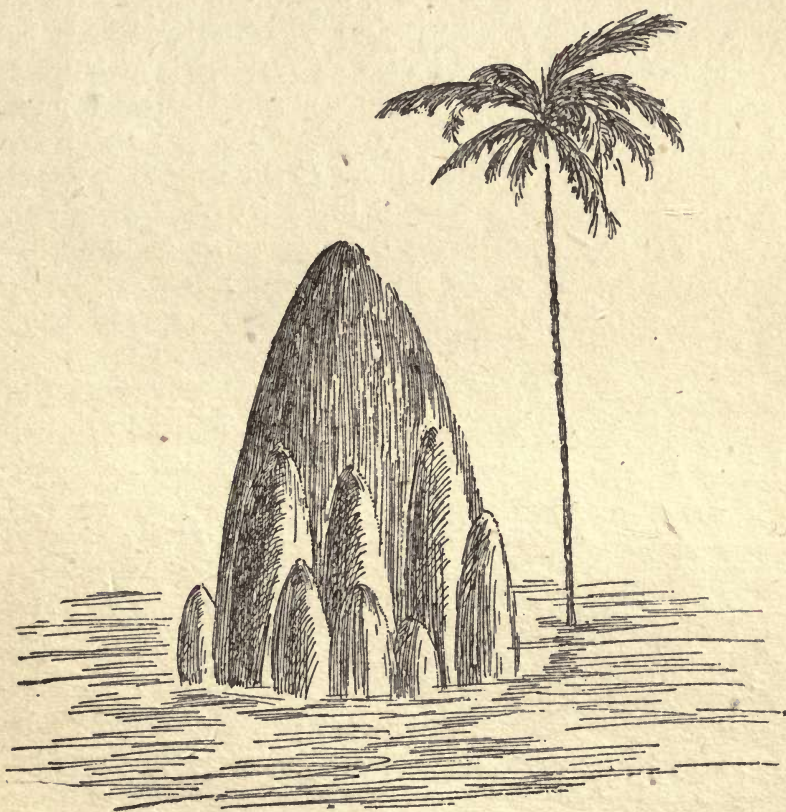
How Animals Work.

away until they have converted the once solid timbers into hollow shells, and the whole structure suddenly gives way and comes down with a crash. Nothing is safe from their attack except iron and tin, and the speed with which they carry on their work of destruction is truly astonishing. But although the Termites are such a pest in the destruction of woodwork, leather, and other materials, they must be counted amongst Nature's scavengers, doing valuable service in the dense African forests by removing all dead and decaying timbers. Nature has numerous scavengers that remove decaying animal matter, eating it or carrying it out of sight, burying it in the earth, where it can do no harm. And it is the vast swarm of Termites which perform a similar function for the plant world, devouring the tissues of all plants and trees the moment they show the first signs of decay.

But although the Termites in their search for dead or decaying timber ascend to the topmost branches of the highest trees, yet they carry out their work of exploration out of sight, and literally *underground*, for they may be said to take the earth with them. The extent to which the Termites indulge their tunnel-building habit sounds incredible until one has actually seen it for oneself, and then one becomes impressed, not only with the magnitude of the labours of these comparatively small, soft-bodied insects, but at the vast amount of subsoil which they bring up to the surface in the course of their work. In the elevated regions of Central Africa, where the colonies of Termites seem to reach their maximum development, the mounds or hills built up by these insects attain to immense size,

Ants and Termites.

and form a characteristic feature of the landscape. These mounds may be dotted together in groups of low conical form, or they may rise singly, like great earth-



White Ant Hill.

towers, their bare sides worn by the action of rain and wind into strange and fantastic channels and groovings, measuring some thirty or forty feet in diameter, and from eight to fifteen feet in height. The Termite is not

How Animals Work.

only a scavenger, but an expert builder, and incidentally one of Nature's ploughs, turning the soil of the tropical regions which it inhabits, not clod by clod, but grain by grain.

Of the manner in which the Termites construct their tunnels and covered ways Professor Henry Drummond gives the following interesting description : " At the foot of a tree the tiniest hole cautiously opens in the ground close to the bank. A small head appears with a grain of earth clasped in its jaws. Against the tree trunk this earth grain is deposited, and the head is withdrawn. Presently it reappears with another grain of earth ; this is laid beside the first, rammed tight against it, and again the builder descends underground for more. The third grain is not placed against the tree, but against the former grain. A fourth, a fifth, and a sixth follow, and the plan of the foundation begins to suggest itself as soon as these are in position. The stones or grains or pellets of earth are arranged in a semicircular wall—the Termite, now assisted by three or four others, standing in the middle between the sheltering wall and the tree, and working briskly with head and mandible to strengthen the position. The wall, in fact, forms a small moon-rampart, and as it grows higher and higher it soon becomes evident that it is going to grow from a low battlement into a long, perpendicular tunnel running up the side of the tree. The workers, safely ensconced inside, are now carrying up the structure with great rapidity, disappearing in turn as soon as they have laid their stone, and rushing off to bring up another. The way in which the building is done is extremely curious, and one could watch

Ants and Termites.

the movement of these wonderful little masons by the hour. Each stone as it is brought to the top is first of all covered with mortar. Of course, without this the whole tunnel would crumble into dust before reaching the height of half an inch ; but the Termite pours over the stone a moist, sticky secretion, turning the grain round and round with its mandibles until the whole is covered with slime. Then it places the stone with great care upon the top of the wall, works it about vigorously for a moment or two till it is well jammed into its place, and then starts off instantly for another load."

The great conical mounds formed by the Termites are not mere refuse heaps, but the citadels beneath whose walls the swarming insects live and rear their young. The interior of the mound is divided up into numerous galleries and chambers, and many of the galleries lead downward far into the earth, where they communicate with other chambers, in whose excavation the Termites have obtained the materials for building up the mound on top. One of the most spacious of these subterranean chambers appears generally to be set aside as the dwelling-place of the Queen Termite and her husband. The Termite colony consists of a vast number of sexually immature workers ; a lesser number of large-headed, powerful-jawed soldiers who take no part in building operations, but mount guard and fight all intruders ; and a perfectly developed male, or king, and female, or queen Termite. The perfect young males and females have wings, and in the spring they leave the nest in large numbers, flying up into the air, and in most cases probably mating with indi-

How Animals Work.

viduals from other nests. The swarms are eagerly followed by various insect-eating birds, so that a very large proportion of these winged Termites perish. The survivors, however, on coming to earth, enter the ground and become the founders of new colonies.

The female, or queen, after impregnation, undergoes the most extraordinary change—her body lengthening and becoming greatly distended, until it looks like a miniature sausage of a sickly, fleshy-white colour. She rests quite helpless, a living bag of eggs, in the royal chamber along with her husband, the so-called king Termite, carefully tended by the workers, who feed the royal couple, stuffing the queen to repletion. As fast as the queen lays her eggs they are carried away to the nurseries by the worker Termites, and the resulting larvæ are fed and tended as carefully and in very much the same fashion as exists in the nests of the true ants. Investigations have shown that in many Termite nests, in addition to the reigning king and queen, wingless males and females, who never leave the nest in which they are born, are kept, but not allowed to pair. They appear to be held in reserve, in case no winged royal pair should be forthcoming, or to replace the queen in the event of her untimely death. Such accidents do happen, and then these wingless pairs become parents. Of the swarming inhabitants of the Termites' nest it is, in most species, only the perfect males and females (kings and queens) who can see, both workers and soldiers being quite blind.

Some species of Termites are tree-dwellers, constructing their nests on trees at a great height, building the large rounded or oval-shaped nest amongst the

Ants and Termites.

topmost branches, eighty or ninety feet from the ground. These immense nests are built of particles of wood mixed with saliva from the Termite's mouth, and possibly with gummy excretions of the tree, worked up into a sort of wood-pulp cement, which can be fashioned into the walls and chambers of the nest. So stoutly are they constructed, and so firmly attached to the trees, that it is impossible to remove them without sawing off the branches to which they are fastened. These arboreal Termites are just as shy of exposing themselves as are their ground-dwelling relations, and, like them, construct long covered ways wherever they go. In the peculiarities of their social life, and in their wonderful architectural powers, the Termites are most remarkable and deeply interesting insects.

CHAPTER IX.

WEAVERS AND SPINNERS.

WE are all more or less interested in the progress of aviation, and inclined to be immensely flattered by what we are pleased to term "man's conquest of the air;" but we have only to watch the flight of any bird as it wings its way serenely through a gale that would instantly wreck the most perfect man-made flying machine to realize how much we have yet to learn before we can hope, even approximately, to approach that perfection of poise, stability, and automatic adjustment of balance by which alone our much-vaunted "conquest" may attain to reality. Birds in the course of their evolution through the countless years which separate them from their reptilian ancestors have become so perfectly adapted in structure for flight through the air, and we are so accustomed to the sight of their swift and graceful progress, that we are very apt to look upon the flight of a bird as a matter of course, and to marvel far more at a bird that cannot fly, like the penguin, than to give a second thought to the wonderful achievement of one that can fly. But although the ancestors of our feathered friends of to-day had learned a good deal more than the first principles of flight long before man appeared on the

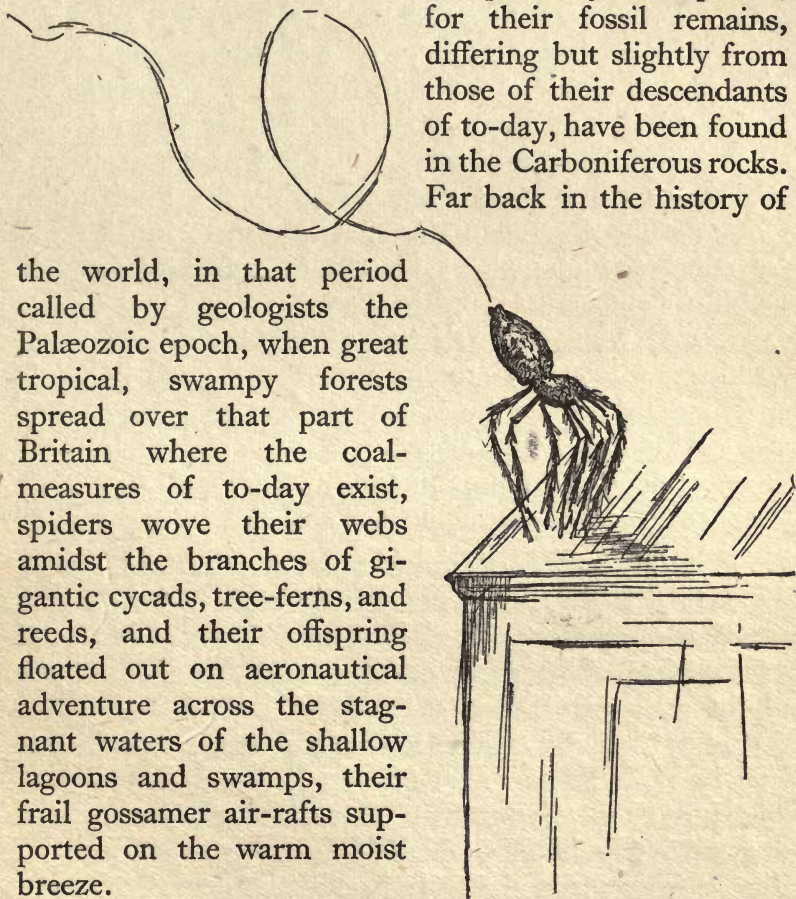
Weavers and Spinners.

scene, they probably cannot claim to be the oldest aeronauts.

No: the most ancient race of Nature's aeronauts are probably the spiders, for their fossil remains, differing but slightly from those of their descendants of to-day, have been found in the Carboniferous rocks. Far back in the history of

the world, in that period called by geologists the Palæozoic epoch, when great tropical, swampy forests spread over that part of Britain where the coal-measures of to-day exist, spiders wove their webs amidst the branches of gigantic cycads, tree-ferns, and reeds, and their offspring floated out on aeronautical adventure across the stagnant waters of the shallow lagoons and swamps, their frail gossamer air-rafts supported on the warm moist breeze.

The habits of spiders have probably undergone but little change since those long-distant days, and we find them a crafty, ven-



How Animals Work.

turesome race, widely distributed in many lands and climates, but the majority very closely agreeing in the general outline of their habits, though varying greatly in size, and always increasing in stature the nearer that we approach the Tropics. But whether we are in tropical South America in the forests of the Amazon region, or at home in England, we shall always find the little gossamer spiders, delighting to go off on aeronautical expeditions, apparently without the least regard or concern as to their ultimate destination. Not infrequently this apparent restlessness bears them far afield and sometimes far out to sea—sometimes, I believe, right across the Strait of Dover; for on more than one occasion hundreds of them have been seen coming aboard in mid-Channel, the threads of their silken air-rafts catching on the spars and rigging of the cross-Channel steamers.

Darwin in the course of his voyage round the world saw these little venturesome aeronauts come aboard his ship on several occasions, and has given the following interesting account of the incident: "On several occasions, when the *Beagle* has been within the mouth of the Plata, the rigging has been coated with the web of the gossamer spider. One day (November 1, 1832) I paid particular attention to this subject. The weather had been fine and clear, and in the morning the air was full of patches of the flocculent web, as on an autumnal day in England. The ship was sixty miles distant from the land, in the direction of a steady though light breeze. Vast numbers of a small spider, about one-tenth of an inch in length and of a dusky red colour, were attached to the webs. There must have been,

Weavers and Spinners.

I should suppose, some thousands on the ship. The little spider, when first coming in contact with the rigging, was always seated on a single thread, and not on the flocculent mass. This latter seems merely to be produced by the entanglement of the single threads. The spiders were all of one species, but of both sexes, together with young ones. These latter were distinguished by their smaller size and more dusky colour. The little aeronaut as soon as it arrived on board was very active running about, sometimes letting itself fall, and then reascending the same thread; sometimes employing itself in making a small and very irregular mesh in the corners between the ropes. It could run with facility on the surface of water. When disturbed, it lifted up its front legs in the attitude of attention. On its first arrival it appeared very thirsty, and with exerted maxillæ drank eagerly of drops of water; this same circumstance has been observed by Strack: may it not be in consequence of the little insect having passed through a dry and rarefied atmosphere? Its stock of web seemed inexhaustible. While watching some that were suspended by a single thread, I several times observed that the slightest breath of air bore them away out of sight, in a horizontal line. On another occasion (25th), under similar circumstances, I repeatedly observed the same kind of small spider, either when placed or having crawled on some little eminence, elevate its abdomen, send forth a thread, and then sail away horizontally, but with a rapidity which was quite unaccountable. One day at St. Fé I had a better opportunity of observing some similar facts. A spider which was about three-tenths of an inch in length, while stand-

How Animals Work.

ing on the summit of a post, darted forth four or five threads from its spinners. These, glittering in the sunshine, might be compared to divergent rays of light; they were not, however, straight, but in undulations little films of silk blown by the wind. They were more than a yard in length, and diverged in an ascending direction from the orifices. The spider then suddenly let go its hold of the post, and was quickly borne out of sight. The day was hot and apparently quite calm; yet under such circumstances the atmosphere can never be so tranquil as not to affect a vane so delicate as the thread of a spider's web. If during a warm day we look either at the shadow of any object cast on a bank, or over a level plain at a distant landmark, the effect of an ascending current of heated air is almost always evident: such upward currents, it has been remarked, are also shown by the ascent of soap-bubbles, which will not rise in an indoors room. Hence I think there is not much difficulty in understanding the ascent of the fine lines projected from a spider's spinners, and afterwards of the spider itself."

These aerial journeys are undertaken not purely as pleasure trips through the air, but in order to seek fresh hunting grounds where a greater abundance of food may be obtained, and are also the recognized means of dispersal of the family in Spiderland. Large families are the rule rather than the exception among spiders, for the mortality in their infancy is very great; and if the young spiderkins, which often number several hundred, had not this means of dispersal far afield, the majority would perish miserably of starvation, or, as sometimes happens, simply form a cannibalistic feast

Weavers and Spinners.

for the sturdiest of the family. In fact, cannibalism is a very general habit among spiders, so that probably a certain proportion of every brood of spiderkins perish in this tragic fashion.

The spiders are Nature's most expert weavers and spinners ; while the delicate beauty and the marvellous skill displayed in the design and construction of their webs and nests always excite our admiration and interest. Indeed, many of the snares constructed by spiders for the capture of their prey will be found on closer inspection to be most perfect and complex in their structure. I am afraid that to a large number of people a spider offers no attractions—in fact, to them it is just “a nasty insect.” Now, as a matter of fact, a spider is not an insect, and very often is a very handsome creature, while it does invaluable service to mankind in devouring innumerable swarms of gnats and flies. It would be out of place here to give a long scientific description of the spider and its exact position in the animal kingdom, and for our present purpose it will suffice to say that the spiders form a connecting link between the true insects and the Crustacea, the division of the animal kingdom to which the crabs, lobsters, shrimps, and prawns belong.

A spider has eight legs, and is divided only into two parts, for there is no division between the head and shoulders ; whereas a true adult insect has only six legs, and has the body divided into three distinct regions—head, chest or thorax, and abdomen. Again, an insect breathes by a network of air-tubes running all over its body, and connected with the exterior by a series of more or less oval pores down the sides of the

How Animals Work.

body, called spiracles. A spider, in addition to these air-tubes, has generally two or four so-called "lung-books" to help it to breathe. We never find a spider with the great compound eyes made up of many cells or facets which are such a characteristic of insect anatomy, the spider being provided only with a series of simple, single eyes, bead-like, and arranged in two rows on the front of the head. Finally, a spider does not pass through a well-marked series of changes or transformations—larva, pupa, adult—as do most of the true insects, the newly born baby spider resembling the adult in all essential features. These are all noticeable features of distinction by which the reader can readily realize the difference between a spider and a true insect.

For the production of the silk used in the building of her snare or nest the spider has on the end of her body a series of glands, or "spinnerets" as they are called, composed of quantities of little tubes, through which the liquid secretion of which the silk is formed passes out, becoming solidified into the fine silken thread on coming in contact with the air. The spider can use just as many of her spinnerets at a time as she considers necessary, and therefore can vary the quality and thickness of the thread to meet her requirements. The feet or claws of the spider are wonderfully modified and adapted to aid her in the work of building her web: they are comb-like in appearance, the little combs being deftly employed in drawing out the threads when the weaving of the snare is in progress, or the cocoon in which she deposits her eggs is being made. These highly specialized claws are also used to seize and hold

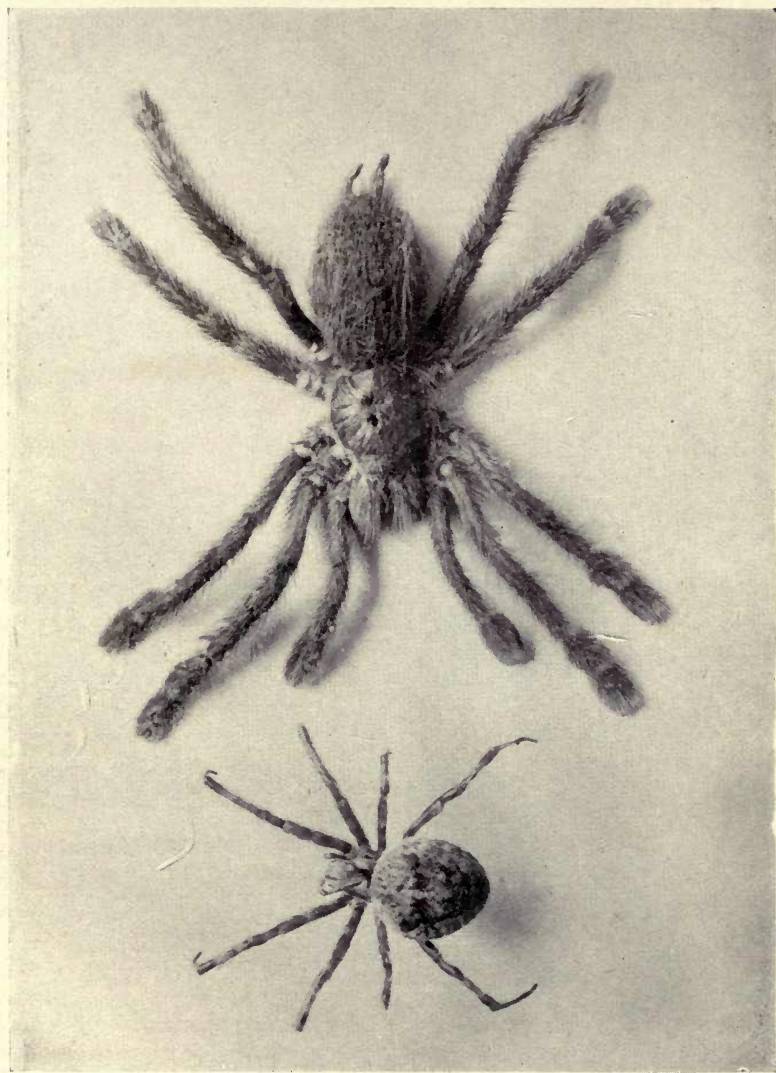
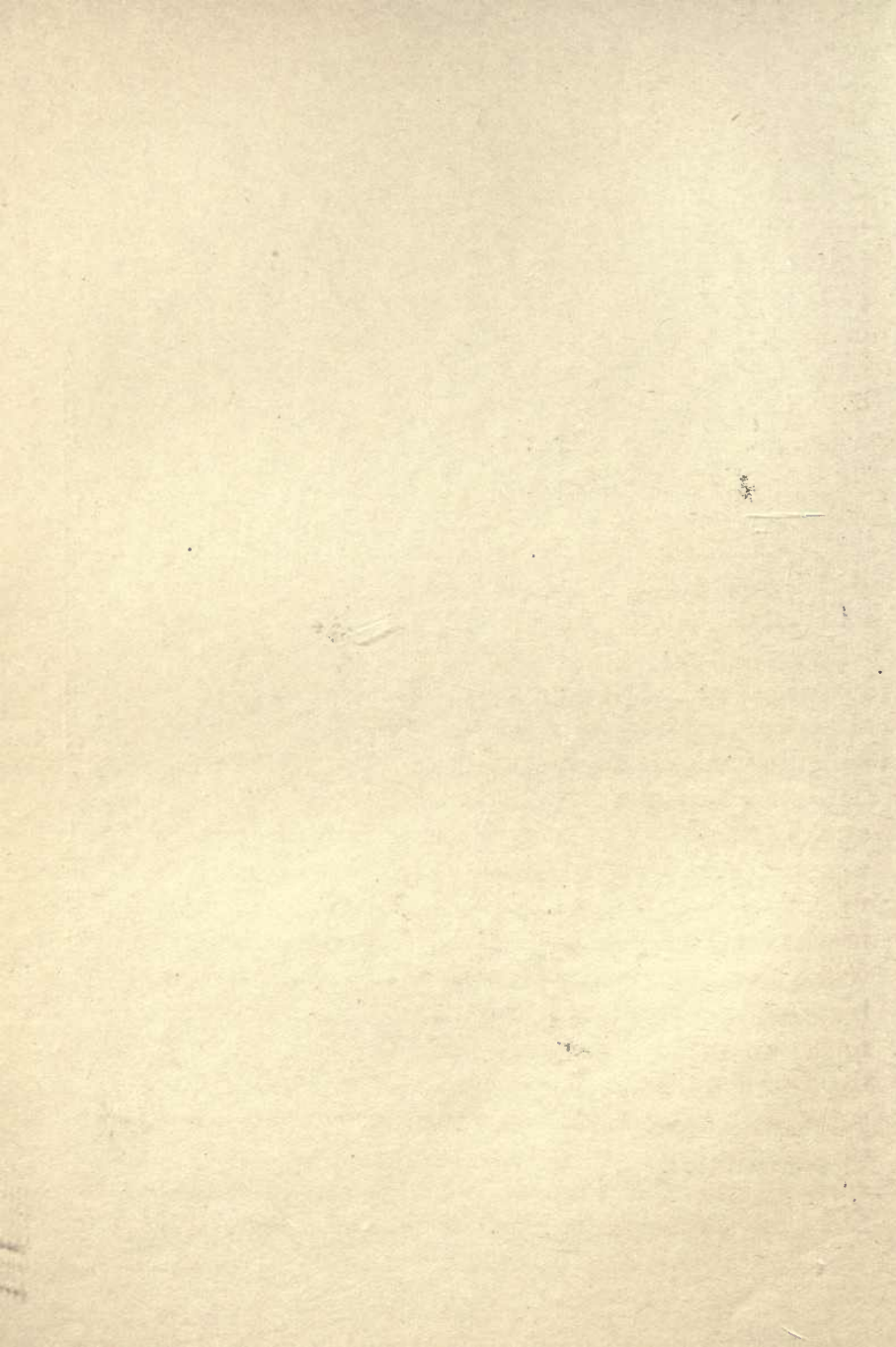


PLATE IX.—THE GARDEN SPIDER AND TARANTULA.



Weavers and Spinners.

the prey. The spider's jaws are truly formidable weapons of offence and defence, hard, sharp, and pointed. Moreover, they are hollow, and have a tiny hole near the needle-pointed tip, through which the poison from a poison gland at the base of the jaw is poured out when the spider fixes her fangs in her victim or foe, as the case may be. The poison is extraordinarily rapid in its action, for within a few seconds after the bite has been administered the captured insect, even a large wasp or a big gad-fly, will be found quite dead.

One of the most striking objects to be found in any quiet, sunny garden, as summer begins to give place to early autumn, is the beautiful circular web or snare of the female spider. These wonderful orb webs, or wheel webs as they are sometimes called, are al-



Spider's Claw.

ways the work of some spider of the Epeiridæ Family, to which our fat, handsome Garden Spider belongs. To watch her actually at work upon the construction of her web is a most interesting sight. Her first care is to lay down the foundation threads which are to form the boundary lines of her web. If she has selected a convenient site where she can reach the necessary points of attachment by walking along the intervening surfaces, then her task will not be a very difficult one. She will spread her spinnerets and rub them against

How Animals Work.

one of the points selected for the attachment of a foundation thread, and then she will walk away trailing behind her a thread which she keeps free from entanglement with objects in her path by the guiding action of one of her hind legs. On reaching the next desirable point of attachment, the spider makes the foundation line taut and fixed by again rubbing her spinnerets against the spot selected. This process is repeated again and again, until the framework of foundation lines, which may be braced in certain places by shorter lines attached to leaves and twigs close at hand to prevent sagging, is completed. The spider pays the greatest attention and care to these first foundation lines, making sure that they are strong and well secured ; for they will have to bear the strain of the web when it is blown by the wind, or when heavy insects fly into it and struggle violently to escape. But Madam Spider does not often select such a convenient site as to be able to crawl from branch to branch with her foundation thread in tow. Indeed, more often than not there are gulfs to be bridged over that would be quite impassable in the ordinary way. But she is in no way disconcerted by this state of affairs, but at once has recourse to the aid of the wind. No, she does not weave an air-raft and float across the intervening space upon it, but having fastened her foundation cable to the last suitable point of attachment, she erects her spinnerets and flings out threads into space ; the silken threads carried by the air currents are borne across the gap, and soon become entangled in some neighbouring object. When this has happened, the spider at once hauls the new line taut, and tests its strength

Weavers and Spinners.

by gently and repeatedly pulling at it; then, having satisfied herself that the line is secure, she proceeds to walk across it cautiously, hand over hand, in an inverted position, carrying with her a second line to strengthen the first; and she will probably make several journeys backwards and forwards, adding extra threads, so as to make the foundation lines thoroughly stout and secure.

The stout foundation lines are placed in such a way as to form an irregular four-sided figure within which the snare will be built, and once they have been successfully fastened in position, the rest of the work is pretty straightforward for the spider. The foundation lines completed, the spider proceeds to fix a diameter line across her framework, from the centre of which she constructs the spokes or radii, generally putting these in alternately, at opposite points of the compass, so as to maintain the stability of her work. At the point where these radiating lines or spokes intersect at the centre of the web, the spider carefully fastens them together by a small flossy mass of silk, which thus forms the central point or hub of the web. The radial lines are constructed by walking from the centre along one that has already been formed, the first diameter line for instance, and fixing the thread to some new point of the circumference. The spokes completed, the spider surrounds the hub of the web with a few turns of spiral thread, which serve to bind more firmly the spokes of the wheel. The general plan of the web is now completed, but the most important part of the work still remains to be done; for the lines so far laid down by the spider are all perfectly dry, and therefore

How Animals Work.

any insect that might blunder into the web would easily be able to free itself. So now Madam Spider must set to work to spin a spiral of viscid thread for the capture of her prey. First of all, however, commencing close to the point where her first few spiral turns of thread end, she proceeds rapidly to work in a spiral thread of ordinary silk with the successive turns about as far apart as she can conveniently straddle her legs, to form a kind of scaffolding, by clinging to which she can put in the viscid spiral, which she starts at the circumference and not at the hub of the web. Now she becomes so closely absorbed in her work that it is quite possible to watch her movements with the aid of a hand magnifying glass without in any way disturbing or alarming her. Her movements become exceedingly careful and deliberate, though by no means slow. With one or both of her hind legs she now proceeds to draw out from the spinnerets successive lengths of a highly elastic line, which she stretches just at the moment of fixing to a spoke or radius, and then lets go with a snap. If we look at this viscid spiral thread with a magnifying glass, we shall see that it is beaded over with little sticky globules, which appear to be arranged with remarkable regularity.

Up to quite recent years it was thought that the deposition of these sticky bead-like globules upon the spiral line was a subsequent operation, and, in view of their vast number and regularity, the circumstance naturally excited much interest. It was estimated by one authority that there were at least 120,000 viscid globules in a fourteen-inch web, and yet the construction of this globule-bedecked spiral had only occupied

Weavers and Spinners.

the spider for about forty minutes. Closer investigation, however, has shown that the thread, on being slowly drawn out, is uniformly coated with viscid matter which afterwards arranges itself into beads, the change being assisted by the sudden liberation of the stretched line at the moment of its attachment to a spoke, as already described.

The Garden Spider having thus completed her snare, takes up her position either in the centre of it, or in some sheltered retreat close at hand connected with the hub by special telegraph lines upon which her sensitive feet rest. For although she possesses eight bright-looking eyes, she is by no means so sharp-sighted as one might suppose; indeed their position is not altogether satisfactory for seeing her prey on the web, and it is far more by sense of touch than by power of vision that the spider not only constructs her wonderful web, but also becomes conscious of the entanglement of an insect within its meshes. When the telegraph lines beneath her feet warn her of the presence of an insect in the web she immediately rushes to the spot. If the luckless victim is small, it is at once seized, twiddled round and round, while at the same moment it is swathed in a silken band of thread poured forth from the spinnerets, and then carried off to the spider's parlour beneath the screen of some leaf at the margin of the web, where it is devoured at leisure. If, however, it is a large insect, and from its struggles seems likely to offer formidable resistance, then the captive is approached warily, and silk is thrown deftly over it from a safe distance, until it has become so thoroughly swathed and bound that it can be seized

How Animals Work.

in safety, and receive its death stab from the poisonous jaws of the spider. Should the insect appear too powerful to be thus overcome, or the spider's larder already stocked to repletion, the spider will release the intruder by biting away the threads which entangle it, so as to save much havoc being wrought with the web by the violent struggles of the captive. The viscid matter on the spiral line dries up after some hours, so the spider has constantly to replace it with a fresh one, even if it has not been destroyed by insects or bad weather. The entire construction of a new web, as we have seen, is a very troublesome business, and so the Garden Spider takes as much care of her web as possible, and spends a great deal of time in patching it up by biting away torn and ragged portions and weaving new lines in their place.

One of the largest North American orb-weaving spiders, popularly called the Basket Argiope, builds a handsome web, somewhat like the web of our Garden Spider, but with a shield-shaped sheet of silk fastened to the spokes or radii in the centre of the snare, while below the shield there is a broad, zigzag ribbon of silk stretched between two consecutive spokes. The Basket Argiope is said to construct her snare in very much the same fashion as our British Garden Spider, the shield and zigzag bands being formed after the general structure has been completed. In order to make these additions to her snare, the Argiope opens her spinnerets to their fullest extent, and draws out a regular stream of fine flossy silk, which is first of all woven over the centre of the snare so as to unite the spokes or radii and to strengthen that part of the snare; then

Weavers and Spinners.

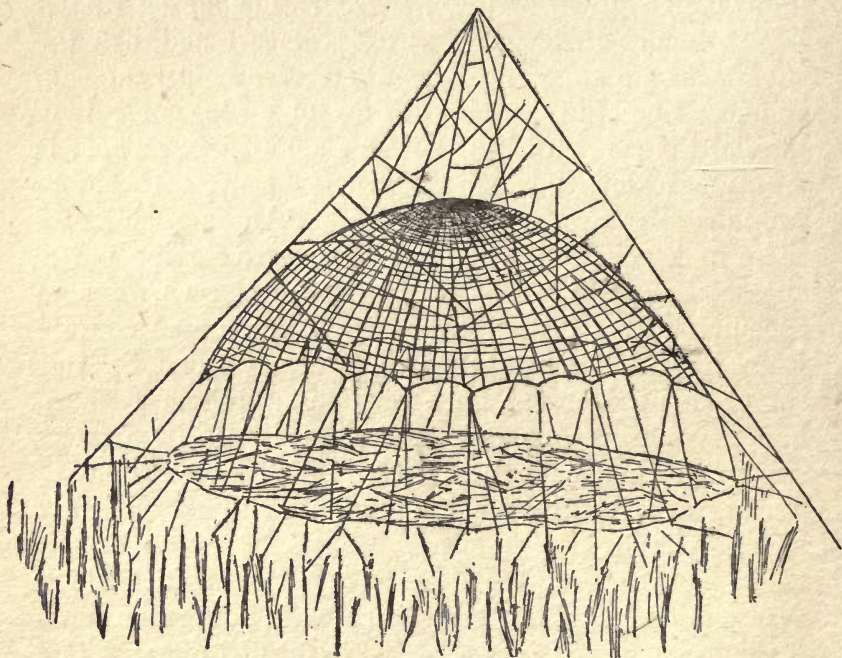
when this is accomplished she places the winding zigzag band in position between two central spokes of the web. The snare completed, the spider takes up her station, head downwards, upon the central shield, in which position she is ready to drop from her snare should danger threaten, or to rush upon any unfortunate insect blundering into her web. The zigzag ribbon is not merely ornamental, but serves to strengthen the snare and probably provide a reserve supply of silk, should an emergency arise calling for an instant supply beyond the powers of the spider's spinnerets. There is a Mauritian spider which constructs a snare with zigzag bands similar to those of the Basket Argiope, and uses them as a reserve supply of silk for enveloping partly entangled insects whose struggles are too vigorous to succumb to the rather scanty supply of thread emitted from its spinnerets at the time of capture. By this means this spider has been seen to overcome a grasshopper much more powerful than itself—by dexterously throwing, with the aid of its hind leg, portions of the zigzag ribbon of silk over its writhing, violently kicking victim.

In Texas there lives a most remarkable spider which first constructs a horizontal orb web, and then proceeds to convert it into a perfectly formed dome. The spider accomplishes this by attaching threads to various points on the upper surface of the horizontal wheel, the central portion of which is gradually pulled up until the height of the dome is nearly equal to the diameter of its base. The snare, however, does not consist of this alone; for when that has been completed, the spider forms a perfect sheet of irregular lines beneath it, while

How Animals Work.

above it she weaves a maze of threads in a pyramidal form. The whole snare is a most wonderful piece of work, and probably one of the most complex built by the orb-weaving spiders.

There is a little orb-weaver that may be found in most gardens and outhouses, which leaves a sector of its web



Dome-shaped Snare.

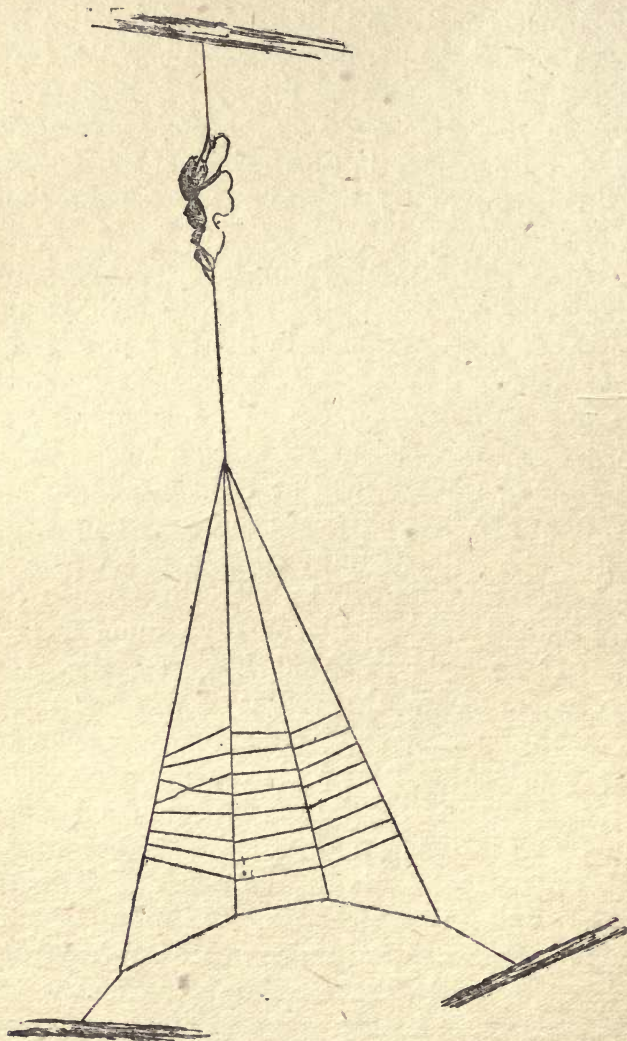
open and entirely free from viscid threads. Through the centre of this sector a telegraph line is carried, connecting the little hub or centre of the snare with the spider's hiding-place at the edge of the web. This shelter is a more or less tubular silk-lined tent woven in a corner among irregular outer lines of the snare.

Weavers and Spinners.

In this snug retreat the little spider sits patiently head downwards, with her sensitive foot upon the telegraph line, awaiting the signal of the approach of prey ; for directly an insect touches and becomes entangled in any part of the snare, its presence is at once communicated to the spider by the vibrations along the telegraph line.

A remarkably clever snare is constructed by the little Triangle or Snap-net Spider, which is rare in England, but quite common in the pine woods of some parts of North America. The little Triangle Spider begins her work by laying down a strong foundation line, and from this she stretches four long sector lines, which meet in a point, and so form a triangle. These four threads she then proceeds to connect by a number of short lines, which, however, are not covered with sticky bands like the orb web of the Garden Spider, but are fluffed out by means of a number of short spines on the spider's hind leg. To the point of her triangular snare the spider now fastens a stout thread, with the other end fixed securely to some object, such as a twig, that is at a conveniently short distance away ; and in this line the spider now takes up her position, upside down, and clinging to the cord with all her eight legs, hauls in the slack of it until the triangular web is stretched quite tight, the loosely coiled slack of the thread resting between her front and hind legs. Directly the trembling movement of this line tells the spider that some insect has struck her net, she instantly lets go the slack with her forelegs, and the web springs back, entangling the unfortunate insect in its fluffy meshes. Should an unusually large

How Animals Work.



Snare constructed by the Triangle Spider.

and vigorous insect be caught, and struggle violently, the little spider will spring her trap two or three times

Weavers and Spinners.

in quick succession, hauling in the line and letting it go as fast as she can, so as thoroughly to entangle her prey.

The Sheet-weaving Spiders weave their snares so closely that when first finished they look like sheets of finest woven muslin. To this family belong the hairy long-legged spiders which weave the familiar cobwebs in the corners and on the ceilings of rooms, and produce the great dusty festoons to be seen in cellars and outhouses. These snares are woven of the finest silk, and take a long time in their construction. First the spider stretches a few delicate foundation lines across the corner of the wall she has selected for the site of her snare, and upon these lines she walks to and fro incessantly, strewing the finest silken threads from her spinnerets upon the foundation lines. So fine is her spinning that some hours elapse before she is able to weave even a moderately stout web; but when once the sheet has been formed the spider devotes a great deal of her spare time to going over it, adding more and more silk from day to day, and in this way gradually thickening it. At one corner of her sheet snare the spider weaves a silken tubular nest, in which she awaits the advent of any insect which may alight upon her snare, when she immediately dashes out and pounces upon it. At first these sheet webs are beautiful objects; but dust and other particles floating in the air settle on them, and soon convert them into unsightly, grubby cobwebs.

A very remarkable weaver is the little Water Spider, which, though strictly an air-breather, spends almost the whole of its life beneath the surface of the ponds

How Animals Work.

and shallow, slow-moving streams which it frequents. That it can live this aquatic life is due to the fact that the long hairs with which its abdomen is densely clothed retain an air bubble when it plunges beneath the water, so that the spider carries its own supply of air to the depths below. Running over the surface of the floating leaves, the Water Spider does not attract one's attention particularly, for she looks just a sooty brown, rather compactly built spider; but the moment she dives beneath the surface her whole appearance changes, and her body looks as if it had suddenly been converted into a globule of quicksilver. At some distance below the surface the Water Spider forms her nest. Her operations are difficult to follow at first, for even in an aquarium, where she will make herself quite as much at home as if she were in her favourite pond, the threads she spins are so fine that it is only when the light strikes upon them at a certain angle that they become visible. Consequently, did we not know what business she is engaged upon as she travels from branch to branch of water weed and back again, we might easily think that she was simply wandering about in a rather feckless sort of way. This is not the case, however, for the spider is really laying down the foundation lines and guide ropes of her nest. Working diligently, she weaves with finest silk a perfect little domed nest, about the size and rather the shape of a large thimble. Her weaving satisfactorily accomplished, the spider next proceeds to bring down a supply of air to fill the nest. Up she mounts in the water, and, raising her abdomen above the surface of the water for an instant, jerks it down again quickly, so as to carry with it a bubble of

Weavers and Spinners.

air entangled in the dense hairs which cover her body. With this she descends to the nest, which she enters, and there proceeds, with the aid of the combs on her feet, to comb out the bubble of air which rises into the dome of the nest. . Again and again this process is repeated, until at last the nest is completely filled with air, and has been converted into a snug, dry chamber—a perfect diving-bell, in fact—in which the spider lives, and in which she will sleep through most of the winter.

That much-abused spider the Tarantula is not only an expert in the art of weaving, but is also a very capable engineer, excavating a cylindrical burrow in the earth, often more than a foot long, and about one inch in diameter, lined with silk throughout its entire length. At about four or five inches below the surface the perpendicular tube is bent horizontally, and, according to the observations of Dufour, it is at this angle that the Tarantula watches for the approach of enemies or prey. According to the same authority, the external orifice of the burrow of the Tarantula is ordinarily surmounted by a separately constructed tube, which is a wonderfully perfect piece of architecture, rising to about an inch above the surface of the ground, and sometimes attaining a diameter of two inches, in which case its aperture is greater than that of the burrow itself. This exterior tube is principally composed of fragments of wood fastened together with clayey earth, and so artistically disposed one above the other that they form a scaffolding having the shape of an upright column, of which the interior is a hollow cylinder. Although all the Tarantulas form a silken-lined tunnel or shaft in which to dwell, they do not always take the trouble to construct

How Animals Work.

the elaborate outer tube. Whether this is due to lack of suitable materials or to laziness on the part of the individual spider it is hard to say. The Tarantula is a near relation to the Trap-door Spiders, and as these appear to display considerable individuality in the construction of their nests, it may be due to individual idiosyncrasy that some of the Tarantula nests lack the outer elaborate tube.

The true Trap-door Spiders are of especial interest, for the homes which they construct for themselves display a wonderful amount of skill and ingenuity. These spiders inhabit tropical and sub-tropical countries, and appear to have a wide geographical distribution, being found in Europe along the shores of the Mediterranean, in Africa, India, Australia, Central South America, and the West Indies. Largely nocturnal in their habits, and their nests so wonderfully hidden as to easily escape the most trained eyes, comparatively little is known about the general life and habits of these intensely interesting creatures, and it is highly probable that, owing to their retiring habits, they have escaped the observation of travellers in many countries, and therefore may be far more numerous than is generally supposed. They have, however, in the person of Mr. J. T. Moggridge, found an able biographer, who devoted many years of an invalid life to the study of their habits, and, indeed, laid the foundation of our present knowledge of their methods of nest-building and general ways of life. The progress of natural science affords many instances of brave and patient men and women who have sought and found mental relief and distraction from their bodily sufferings by the close observation

Weavers and Spinners.

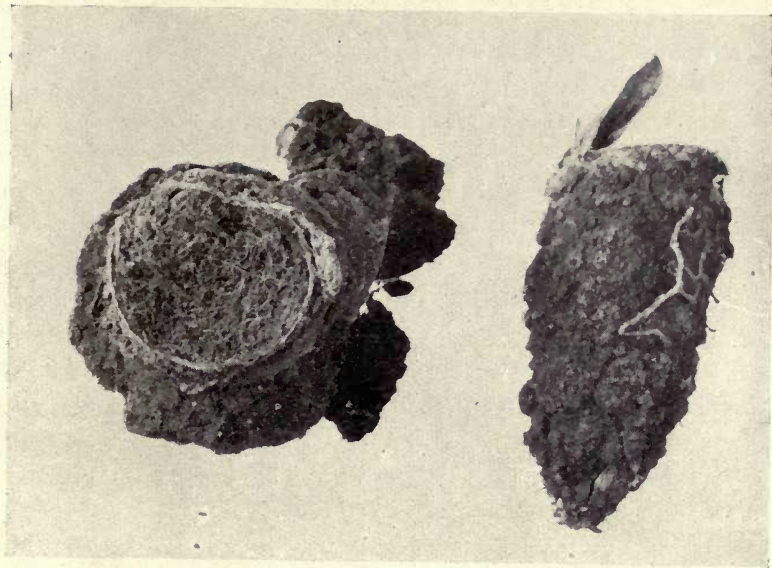
of the wonders of Nature ; and their labours, carried on under such adverse conditions, have often been rewarded by discoveries which have proved of incalculable service to the advancement of our knowledge of those subjects to which they have devoted their attention. One of the noblest examples is, I think, to be found in the life of the great Charles Darwin, whose greatest and most fruitful labours may be said to have been carried out under conditions of health almost intolerable—conditions that would have quickly converted most people into peevish, self-absorbed, useless members of society ; yet through all the long years of bodily suffering he devoted every possible moment to those epoch-making scientific investigations that made his name famous throughout the world.

The nest of the Trap-door Spider, even in its simplest form, is a wonderful piece of workmanship, requiring a considerable amount of patience, skill, and ingenuity in its construction. According to Mr. Moggridge, four types of trap-door nest, properly so called, may be distinguished. All the four types of nest consist of a tube excavated in the earth to a greater or less depth, in every case lined with silk, this lining being continuous with the lining of the door or doors of which it forms the hinge. Two of the types of nest are almost exactly alike, except in the construction of the trap-door, which in one consists of a thin, circular or oval sheet of silk, which flaps down loosely over the tube entrance—called the wafer door ; while in the other the door is much thicker, made of layers of earth and silk, and so contrived that it tightly closes the mouth of the tube, which is bevelled to receive it much as a cork closes

How Animals Work.

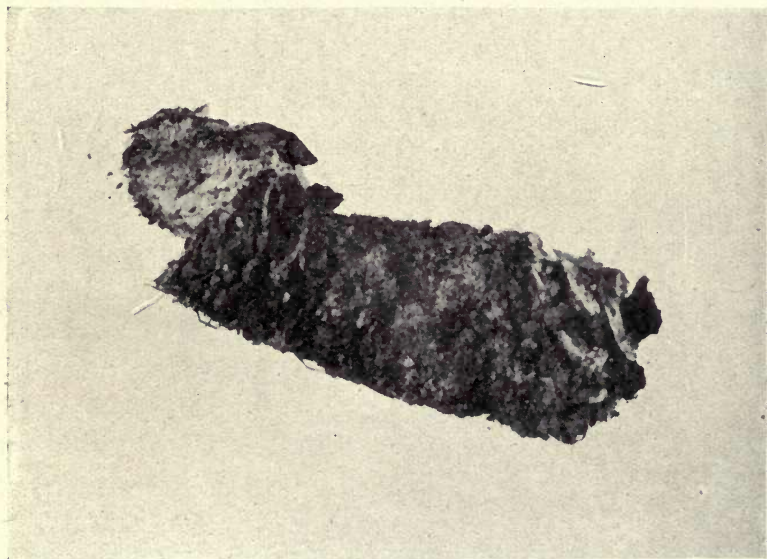
the neck of a bottle. This type is called the "single-door" cork nest. In forming the wafer type of door the spider covers the entrance to the nest with a closely woven sheet of silk, which she afterwards bites away round the edge, except at the point where the hinge is to be. The cork type of door is much more complex. First the spider weaves a covering of silk, as in the construction of the wafer door; then she brings earth in her jaws and lays it on top, binding it down with a second layer of silk, and this process she repeats until the requisite thickness is obtained. The third type of nest, again, is a single descending silk-lined shaft; but it has two doors, one of the wafer type at the top, level with the surface of the ground, the second door being at a little distance down the tube. The fourth type of nest is the most complex of all, for the spider constructs in this instance a Y-shaped burrow, one arm of which, however, does not always reach to the surface; and the second door of this nest, instead of being across the descending shaft at a little distance from the surface, hangs at the fork of the Y in such a manner as to connect the bottom chamber either with the entrance or the blind-ended branch. To the outer surface of the door covering the top of the nest the spiders attach leaves, moss, or small twigs, which most effectually hide the entrance. The Trap-door Spiders appear to be greatly attached to their nests, which they enlarge and repair when needful; and they begin burrowing very early in life, building miniature tubes, which in all respects exactly resemble those of their parents.

The cork-door nest is the simplest form, and its



NESTS OF AN AUSTRALIAN TRAP-DOOR SPIDER.

This spider constructs a "cork"-shaped door to its nest.



A TRAP-DOOR SPIDER'S NEST, WITH "WAFFER" TYPE OF DOOR.

Weavers and Spinners.

chief claim to our admiration rests in the wonderful perfection of workmanship which the door generally exhibits, and the complete concealment which it affords when closed. Indeed, this type of door generally fits so tightly, owing to the accurate adjustment of its sloping sides to the bevelled rim of the nest, that it affords a certain amount of resistance to opening from above, even when the inhabitant of the nest is absent from home. When within its nest, some species of Trap-door Spider will endeavour to keep the door closed should any attempt be made to open it—offering the most determined resistance. Of the manner in which the spider holds on to her door to prevent its being opened, Mr. Mogg-ridge gives the following interesting account :—“ No sooner had I gently touched the door with the point of a penknife than it was drawn slowly downwards, with a movement which reminded me of the tightening of a limpet on a sea-rock ; so that the crown, which at first projected a little way above, finally lay a little below the surface of the soil. I then contrived to raise the door very gradually, despite the strenuous efforts of the occupant, till at length I was just able to see into the nest, and to distinguish the spider holding on to the door with all her might, lying back downwards, with her fangs and all her claws driven into the silk lining of the under surface of the door. The body of the spider was placed across, and filled up the tube, the head being away from the hinge, and she obtained an additional purchase in this way by blocking up the entrance.” The excavation of the shaft is no light undertaking ; for the spider is not very active in her movements, and the digging has to be done chiefly

How Animals Work.

with her jaws (for she has not been observed to use her feet or legs for the purpose). Therefore the earth is dug out in little fragments, every morsel as it is dislodged being carried to some distance from the nest. As the shaft gradually deepens, the spider ceases from her digging operations from time to time, to shore up the walls with patches of silk, and so prevents their sudden collapse, or caving in upon her. Once the chamber has been completed, the spider covers the walls with several dense layers of silk.

Describing the double-doored nests, Mr. Moggridge states that these "have a thin and wafer-like door at the mouth of the nest, and from two to four inches lower down a second and solid underground door. These lower doors are characteristic of the nests to which they belong—that of the branched nest being long and more or less tongue-shaped, while that of the unbranched double-door nest is somewhat horse-shoe shaped. In the branched double-door nests the upper door does not fit into, but merely lies upon, the mouth of the tube, the elasticity of the hinge and its own weight being sufficient to keep it closed. The lower door is suspended by a hinge placed at the apex of the angle formed by the bifurcation of the tube, and is hung in such a manner that it can either be pushed upwards so as to lie diagonally across and block the main tube, or be drawn back so as to fit into and close the entrance to the branch. When the lower door is drawn back so as to close and conceal the entrance to the branch, it lies in the same plane, and closely corresponds in curvature with the lining of the main tube, and almost appears to form part of it. What, it may

Weavers and Spinners.

be asked, is the use of the branch? I do not think that we can draw any safe conclusion from what takes place when we dig out a spider as to what would occur if she were besieged by one of her natural enemies, such as ichneumons, sand-wasps, or centipedes. Let us suppose, however, that one of these creatures has found its way into the nest, and is crawling down the tube. What will happen? Why, in the first place, the spider will slam the second door in the face of the intruder, and then, if worsted in the pushing match which follows, quickly draw this door back again and run up into the safety branch, when the enemy, after descending precipitately to the bottom of the main tube, will look in vain for the spider, as it searches on its way up for the secret passage now closed by its trap-door."

In the unbranched double-door nest the thin and wafer-like surface door appears to be constructed by the Trap-door Spider to serve principally for concealment, while the lower one is for resistance. This lower door is made out of earth encased in strong white silk, and has at the end opposite the hinge a sort of silken flap, by which the door when firmly jammed into the tube on the approach of an enemy may be pulled down again as soon as the danger is over. But of all these nests, the cork type, as Mr. Moggridge calls it, is the cosmopolitan form, which ranges round the world, and, strange to say, is built by many different spiders belonging to distinct genera. In fact, "this very perfect bit of mechanism appears to be the common inheritance of these several spiders, separated though they are by wide intervals of geographical space as well as of structural divergence."

How Animals Work.

While most of the Trap-door Spiders appear to be nocturnal in their habits, there are exceptions to the rule. Thus one inhabiting the island of Formosa, in the China Seas, is habitually to be seen outside its nest during the daytime, and is said to attract attention by "staring" at any one who may approach, and then hurrying off to its nest and closing the door after its entry. A black Trap-door Spider, which is very common about Parramatta, near Sydney, in Australia, is also to be seen constantly abroad during the daytime.

The following is an account of the nocturnal habits of a Trap-door Spider which inhabits the island of Tinos in the Grecian Archipelago. It was observed by M. Erber, and shows the remarkable cunning displayed by these creatures. "On my return journey from Rhodes I stayed for a fortnight in the island of Tinos, and among other things I captured several specimens of the so-called Trap-door Spider, and with much trouble procured an entire tube and trap-door. I dug out several of these tubes, but failed to find either the remains of food or excrement. So there was nothing for it but to devote a couple of nights to watch these creatures. With this view I selected a place where many spiders had excavated their tunnels, and availed myself of a moonlight night for my observations. Shortly after nine o'clock the doors opened and the spiders came out, fastened back the trap-doors by means of threads to neighbouring blades of grass or little stones, then spun a snare about six inches long by half an inch high, and afterwards returned quietly to their holes. I had so chosen my position that I could see three of these spiders at the same time. I now cap-

Weavers and Spinners.

tured a specimen and put it into spirits, and in a short time saw entangled in the nest of one of the remaining spiders a *Pimelia*, and of the other a *Cephalostenus*, both rather hard-lived night-flying beetles, which were seized by the spiders, and the latter, after sucking out the juices, carried the empty bodies to a distance of several feet from their holes. All these events happened in about three hours, after which time I allowed the two spiders to remain undisturbed, and returned to the house. Early next morning I revisited the spot, and then perceived that these two spiders had entirely removed the net which they made the preceding night; but the entrance to the nest of the spider which I had captured still remained open, and I could clearly trace the shape of its snare on which the heavy morning's dew lay. The upper threads were isolated, but the snare became thicker as it approached the ground. I found that these snares had, strange to relate, been gathered up by the two other spiders, fastened on to the door, and smoothly spun over; and on making a vertical section of the doors, which were nearly a quarter of an inch thick, I discovered that they were composed of several layers." The young spiders, which hatch from the eggs deposited by the female in her nest, are soon turned out by their mother into the world to fend for themselves; which they seem fully capable of doing, for they at once proceed to excavate miniature shafts, line them with silk, and cap them with perfect trap-doors, so that they are when finished identical in all details with the home of their parent.

Many spiders display great skill in the weaving of the cocoons in which they place their eggs. While some

How Animals Work.

spiders just weave a loose, fluffy mass of silk, without any particular shape, others will be found to take the greatest pains and trouble to weave their cocoons into all sorts of graceful shapes, and in some cases trim them with pieces of leaves and grass, and other materials ;



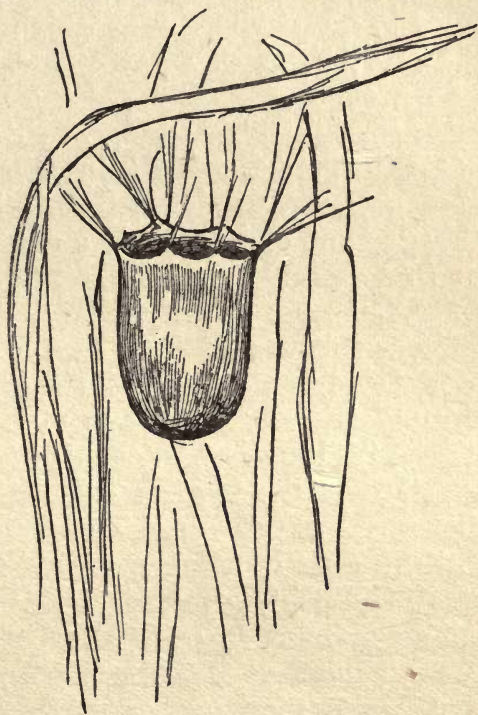
Cocoon of Basket Spider.

these extraneous objects being attached to the cocoon, not so much for its adornment, but the better to hide it from the eyes of foes. This is particularly well demonstrated in the case of the little so-called "Fairy-lamp" or "Mason" Spider, which weaves a most delightful little casket of glistening white silk that looks for all the world like a fairy Japanese lantern as it swings on some slender grass

or heather stem. But no sooner is this charming piece of weaving accomplished than the spider sets to work ruthlessly to destroy its striking beauty by daubing it all over with mud. Up and down the stem of the plant to which she has attached her cocoon the little

Weavers and Spinners.

spider travels with tireless energy, patiently carrying up pellet after pellet of damp mud, and plastering them on all over the cocoon. With the aid of her palps and forefeet she carefully smooths and presses the earth pellets into position, turning herself about from time to time to wind a few threads round the earthy mass, the better to secure it and prevent its being washed away by the rain. When her task is finished, no part of the glistening cocoon remains visible; it has, in fact, been converted, to all appearance, into a little lump of dried mud.



Cocoon of Banded Spider.

There is a handsome relation of our large Garden Spider which, from the bands of yellow, black, and silver encircling her ample body, is known as the Banded Spider, and is the weaver of a particularly beautiful cocoon. In shape, the cocoon is something like a tiny balloon, suspended upside down, and about the size of a pigeon's egg. Its outer covering is formed of glistening white silk, so closely woven as to resemble the

How Animals Work.

softest satin, ornamented at its upper end with silken bands of black and brown in the form of a wavy pattern. Inside it has a bed of soft reddish-brown silk all puffed out into a fluffy mass, in the midst of which, safe and warm, repose the spider's precious eggs. Quite a thick wad of white silk is woven by the spider to fill the neck of this elaborate cocoon, which is finished off with a dainty scalloped edge. Another spider weaves a cocoon resembling a cup in shape, to which a thick lid is fitted, the whole being slung amidst the stems of grasses and wild plants, which have been drawn closer around the cocoon by a network of silken threads so as to provide additional protection. The cocoon encloses a mass of soft silk which enshrouds the egg-pad composed of loosely woven silk. Caudata, the little tailed spider, does not trust her cocoon to the swaying stems of branches, nor does she believe in placing "all her eggs in one basket." She cuts out the spirals from the upper section of her orb web, and in this space weaves a series of bead-like cocoons, from three to eight in number, each about the size of a pea, formed of fairly dense yellowish silk, and each containing a number of eggs. Ultimately the cocoons become more or less decorated with the remains of beetles and flies, mother spider in this way utilizing the uneatable fragments of her victims as a screen to further protect her cocoons. Another spider, called Reparium, constructs a silken tent about one and a half to two inches in length and some half an inch in diameter, the exterior of which she covers with pellets of earth, bits of grass, withered leaves, or any similar plant debris that may be at hand, and which will serve

Weavers and Spinners.

to effectively hide the golden treasure of her egg-cocoons which are slung within the tent. The Wolf, or Hunting Spiders, which do not construct elaborate snares, weave oval or round silken cocoons to contain their eggs, and either carry them about attached by a silken thread to their body, or hide them away in nooks and crannies under the bark of trees or in the rocks, or cracks in the brickwork of outhouses.

Many caterpillars are expert weavers, spinning lovely silken cocoons in which to pass the pupa stage of their transformations, or silken webs to screen them from view. Thus the little caterpillars of the Lackey Moth as soon as they escape from the eggs unite into companies and envelop themselves in a silken web, which covers the leaves and branches in their neighbourhood; and beneath this common shelter they remain until they have considerably increased in size, when the little party breaks up and the individual caterpillars spread over the trees. The caterpillars of the Processionary Moth, which is fairly common in some parts of France, collect in families which may contain hundreds of members. They form an irregular web, in which they remain during the daytime, issuing forth at eventide to feed. Such a common web or nest may cover a considerable part of the trunk of a tree; and it consists of several layers of silken web, one over the other, but very intimately woven together, its weaving having been accomplished by the united labours of the caterpillars. These caterpillars have gained their popular name from their mode of progress when going forth to feed. During the daytime they remain closely packed together beneath the shelter

How Animals Work.

of their silken nest, hardly showing any movement ; but as soon as the sun has set they awaken and begin to stir. A single caterpillar is then seen to issue from the nest and begin to ascend or descend the trunk of the tree ; immediately it is followed by a second and a third ; then comes a rank three or four abreast, which is followed by one of many more, the ranks going on increasing in their numbers pretty regularly at first, but becoming confused as the main host leaves the nest. After feasting on the foliage of the tree, the same order is taken up, one caterpillar which is apparently indistinguishable in appearance from his fellows invariably leading the array, and the host marches back to its nest. Should the caterpillars, however, have had to march a considerable distance from the original nest in their search for food, they may elect to camp on or in the vicinity of their newly discovered feeding ground, in which case all hands, or rather mouths, set to work, and a new silken cover is woven.

But the Silkworm, the caterpillar of the Silk Moth, is the most important of all insect weavers, for its silk has been used by mankind for many, many centuries. Indeed, the Silkworm and the cotton plant have played very important parts in the social and commercial progress of mankind ; they have helped forward the march of civilization, strengthened the bonds of friendship between nations, and to-day give employment to many thousands of people. The discovery of the value to man of the silk used by the Silkworm in the construction of its cocoon is lost in the mists of time, but the Chinese are generally supposed to have been the discoverers of its value and the first

• Weavers and Spinners.

to utilize it. One of the stories connected with the discovery relates that the Emperor Hoang-ti, who lived 2,600 years B.C., desiring that his wife, the beautiful Si-ling-chi, should contribute to the happiness of his people, charged her to devote herself to the study of the Silkworm, and to try to find a way by which its threads might be utilized. To this end Si-ling-chi caused a great quantity of these insects to be collected, which she fed herself in a place especially set aside for the purpose. And to such good purpose did she prosecute her studies, that she not only discovered the means of rearing the Silkworms in captivity, but also the manner of winding off the silk from the cocoons and using it in the manufacture of fabrics.

Another writer states that "up to the time of this queen, when the country was only lately cleared and brought into cultivation, the people employed the skins of animals as clothes. But these skins were no longer sufficient for the multitude of the inhabitants; necessity made them industrious; they applied themselves to the manufacture of cloth wherewith to cover themselves. But it was to this princess that they owed the useful invention of silk stuffs. Afterwards the empresses named by Chinese authors, according to the order of their dynasties, found an agreeable occupation in superintending the hatching, rearing, and feeding of Silkworms, in making silk, and working it up when made. There was an enclosure attached to the palace for the cultivation of mulberry trees. The empress, accompanied by queens and the greatest ladies of the court, went in state into this enclosure, and gathered with her own hand the leaves of three

How Animals Work.

branches which her ladies-in-waiting had lowered until they were within her reach. The finest pieces of silk which she made herself, or which were made by her orders and under her own eye, were destined for the ceremony of the grand sacrifice offered to Chang-si." *

Many and wise were the laws enforced by the emperors of each succeeding dynasty for the cultivation of the mulberry trees and the rearing of Silkworms ; while for many centuries it was forbidden, under pain of death, to export from China the eggs of the Silk Moth, or to give any information as to the art of obtaining the silk ; only the manufactured article could be sold outside the empire. Legend has it that the first eggs of the Silk Moth were brought from China to Constantinople by two monks of the order of St. Basil during the life of the Emperor Justinian, and that they were brought from the Far East concealed in the hollow pilgrim staffs of the two adventurers. Certain it is that the Emperor Justinian caused to be established at Constantinople silk manufactures in which skilled Asiatics, who were forbidden to disclose their knowledge to strangers, were employed. In Southern Greece the industry quickly assumed immense importance, and for many centuries Constantinople and Greece supplied the whole of Europe with Silkworms.

What of this master spinner of insect life, whose silken thread gives employment to thousands, and has also helped many to amass large fortunes ? It is not an alluring-looking insect in its general appearance : many of its silk-spinning relations wear far brighter liveries, and are adorned with spots of colour, blue as

* Duhalde, *Description de la Chine*.

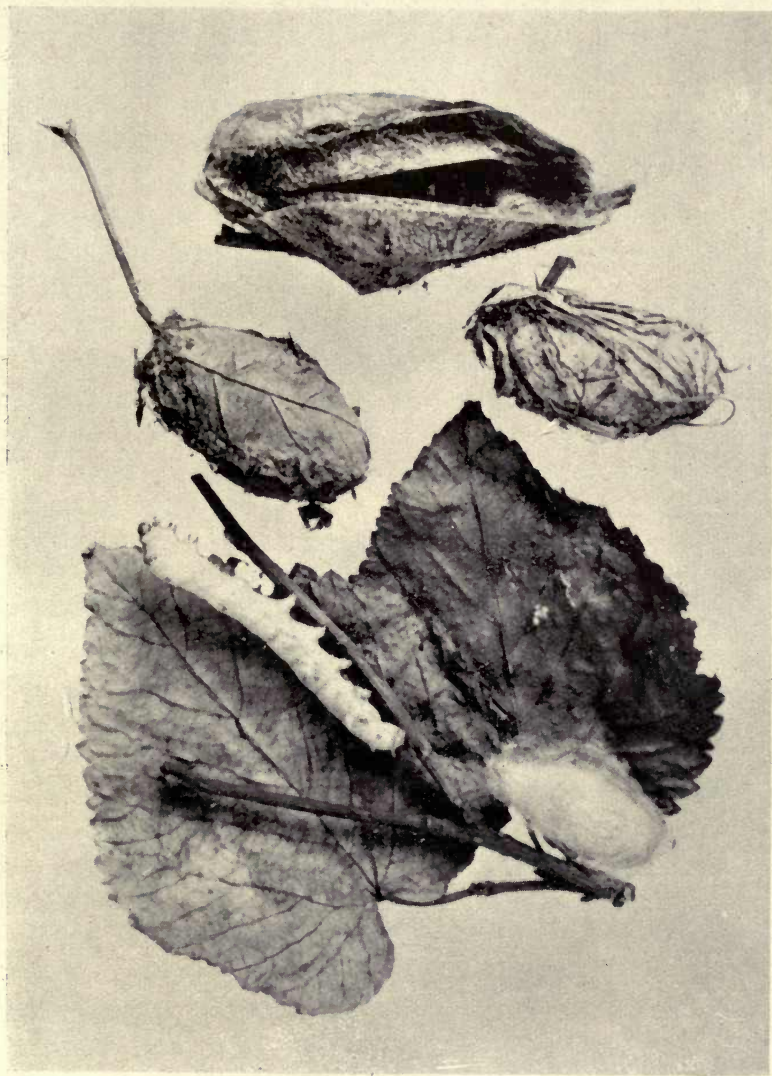


PLATE XI.—WORKERS IN SILK.

The common silkworm and its cocoon, and large cocoons formed by other silk weavers.

Weavers and Spinners.

sapphires, green as emeralds, red as rubies; yet none of them produce threads of such purity, brightness, and fineness as the humble Silkworm, dressed like a workman in a dirty white blouse, although many of them make a far larger cocoon. Most of us as children have kept Silkworms, so that we are more or less familiar with their dingy white colour and general appearance; with their beautiful golden cocoons, and pretty, soft, docile little moths that come forth from those silken chambers. The weaving of that silken cocoon is really a very wonderful performance. From the time the Silkworm emerges from the egg until it is fully grown and ready to begin the weaving of its cocoon, it has done nothing but eat from morning to night, save for brief intervals when it has had to pause to cast its skin—five times in all; and has hardly moved, save to crawl over the mulberry leaf to a fresh position. Now, however, having attained to its full size, it becomes restless, wandering away from the leaves, and continually raising its head and moving it from side to side, seeking a suitable spot to which it may cling during the process of weaving its cocoon. Having found a position to its liking, the Silkworm now sets to work to accomplish its task. At first it throws out on all sides some rough fluffy silk called “refuse silk,” and destined for fixing the cocoon. The foundations, so to speak, having been thus laid down, the Silkworm proceeds to unwind its long silken thread, bending it backwards and forwards to the several points of attachment, and gradually enclosing itself in a silken cell. For some time it is possible to see the shadow of the Silkworm through the veil of silk, as it ceaselessly

How Animals Work.

moves its head backwards and forwards, a veritable living shuttle weaving a golden canopy, until at last the walls of the cocoon grow so thick that it is quite hidden from sight. For four days does this indefatigable weaver labour at the spinning of its cocoon, and by the time it is finished it has been calculated that the Silkworm has moved its head backwards and forwards three thousand times, and unwound a thread about one thousand metres in length. The labour expended upon the construction of the cocoon, and the amount of material secreted by the silk-producing organs of the caterpillar, seem truly prodigious when we consider the comparatively small size of the insect ; indeed, it has been estimated that forty thousand cocoons would suffice to surround the earth at the Equator with a single silken thread.

Though the Silkworm is the greatest weaver of them all, there are many caterpillars that display considerable ingenuity in the construction of their cocoons, using various building materials in addition to their silk secretion. The caterpillar of the Sycamore Moth (*Acronycta aceris*), which is covered with tufts of yellow hair, first spins an outer wall of pure silk to its cocoon, and when this is thick enough, proceeds to tear out its hair, according to Réaumur, in the following manner, to form a lining :—" Its two jaws are the pincers the caterpillar uses in seizing a portion of one or other of the tufts of hair ; and when it has seized it, it tears it out without much difficulty. It at once places this against the tissue it has already commenced, in which it entangles it at first simply by pressure ; it fixes it then more securely by spinning over it. It does not

Weavers and Spinners.

leave off tearing out its hairs until it has entirely stripped them off. When the caterpillar has taken between its jaws and torn out a whole tuft of hair, the head carries it and deposits it on some part of the lower surface of the cocoon ; but it does not leave the hairs of such a large parcel together. The next moment one sees its head moving about very quickly ; then, taking a portion of the hairs from the little heap, it distributes them about on the neighbouring parts of the cocoon. If one opens one of these shells before the caterpillar has become a chrysalis, the larva, which is quite naked, and which was only known by its hair, can be no longer recognized."

The larva of the Tiger Moth, that hairy caterpillar which children call the " Woolly Bear," also makes use of its hairs for strengthening the tissues of its cocoon, but does not heroically pluck them out, Réaumur stating that it cuts them off. The operations of those caterpillars which excavate a chamber beneath the surface of the soil in which to pupate, often lining it with a thick tapestry of silk or weaving grains of earth into the silken cocoon, are very difficult to observe. Réaumur, in the course of his numerous experiments and researches, was enabled to witness the reconstruction of part of the walls of the earth and silk cocoon formed by the caterpillar of the Mullein Moth by taking one from the ground, partially tearing it open, and placing it in a glass vessel containing some earth. The caterpillar at once started to repair its damaged cocoon, and began by coming almost entirely out. It moved its head forwards as far as was necessary to enable it to seize a particle of earth. As soon as it had got its load

How Animals Work.

it re-entered the interior of the cocoon. It deposited the grain of earth, and came out again immediately to pick up another grain, which it carried likewise into the interior of the cocoon. This operation was continued for more than an hour, by which time the caterpillar had collected quite an appreciable quantity of earth particles within its cocoon. It then began spinning over one part of the edges of the opening, and after it had woven a loose band of silken threads the caterpillar's head disappeared from view for a moment, only to return holding a pellet of earth in its jaws, which it promptly entangled in the threads. Gradually working round the edge of the torn gap in its cocoon, alternately spinning threads and entangling pellets of earth, the caterpillar rendered the diameter of the opening smaller and smaller. When the opening was at last reduced to a circle of only a few lines in diameter, the caterpillar drew threads from one point of the circumference to another on the opposite side, thus covering the aperture with a rather open network. As soon as this web was finished the caterpillar placed a grain of earth against it, and by pushing and pressing it, made it pass through the web until it reached the exterior, and so in succession more grains were brought and forced into position, until the whole of the silken web was hidden from view.

There is an interesting group of caterpillars the members of which are quite wise in the art of dress-making, and which are sometimes called "Basket Worms." To protect their soft bodies, these little caterpillars dress themselves up in garments made of leaves, blades of grass, small twigs, or even little stones

Weavers and Spinners.

woven together with silky threads ; while one weaves of silk alone a structure that is exactly like a small snail shell in appearance ; in fact, the first specimens sent to the British Museum were sent as being snail shells to be found in great numbers near Lake Issyk-Kul, in Central Asia. One of these caterpillars with the aid of its jaws cuts little pieces of wood, each piece of the proper length, and these are all woven together lengthwise into a wonderful spiral garment. Another may be found wandering over heaths and grass-lands dressed in a garment made entirely of very accurately cut pieces of leaf. The caterpillar takes a great deal of trouble in making this odd-looking garment, fastening the leaves most neatly together, and arranging them in rows one above the other like a series of little flounces ; while to the top of this costume it adds a spiky collar of tiny wood chips, or of blades of grass. One dress has to last the little insect throughout the caterpillar stage of its life, and so it must needs from time to time enlarge it. This is done by making a slit part of the way down one side of the dress, and fastening into the gap a fresh piece of material made up of silk and vegetable matter woven together. These caterpillars belong to the Psyche family, and have a very



Cases of the Basket Worm.

How Animals Work.

wide distribution, being found in tropical countries as well as in Europe and Great Britain.

The caterpillars of the familiar Clothes Moth (*Tinea*) are all more or less expert dressmakers, and unfortunately, while busily engaged in making garments for themselves, they are at the same time ruining ours. The caterpillar of the Wool Moth, directly it escapes from the egg, sets to work with its jaws to snip off the tiny shreds of the material on which it is resting, and weaves these together into a beautiful, warm, tubular coat, which is enlarged by additions of material from time to time as growth makes necessary. The caterpillar of the Fur Moth does even more damage; for not only does it bite off the hairs to weave into a garment, but, the coat finished, it will wander about over the skin, making paths for itself in the fur by biting away every hair that comes within its reach.

CHAPTER X.

MINERS, DIGGERS, AND CARPENTERS.

FOR countless generations the more primitive races of mankind have dug pitfalls for the capture of their prey. Yet, ages before the first human hunter had thought of this method of snaring the larger and fiercer beasts of the wild that were more than a match for his strength or primitive weapons, a small insect had become a past master in the art of digging pitfalls for the capture of its prey, and has handed on its craft through the ages down to its descendants of to-day. This insect digger of pitfalls is not a particularly intelligent-looking creature. It has a soft, roundish, oblong body covered with warty excrescences and hairs, and comparatively weak legs ; but the stout, flat head is armed with a pair of formidable jaws. This is the famous Ant-lion, and a glance at the illustration (Plate VI.) will show you that at this, the larval stage of the insect's life, it is no beauty. It is fairly common in the south of Europe, frequenting sandy, open places where there is plenty of sunshine, and living at the bottom of the funnel-shaped pitfall which it excavates in the sand.

The labour of digging out the pit is really considerable. First of all, crawling backwards with rather a

How Animals Work.

jerky motion, the Ant-lion traces in the sand a circular trench, which may vary from one to three inches in diameter, and marks the edge of the snare. Having completed this, the insect proceeds laboriously to dig out the space thus marked to the required depth. This is accomplished by moving round and round within the circle, always backwards and in a descending spiral. In this circular progression the action of the feet brings the sand on to the surface of the flat, shovel-like head, and then by a sharp jerk of the head the grains of sand are thrown beyond the boundary of the pit. So active is the larva that a constant shower of sand issues from the pit during the process of its excavation. This toilsome task accomplished, the Ant-lion lies snugly in wait at the bottom of the pitfall, its ungainly body hidden beneath the sand, and only the top of the head or tips of the jaws showing. Nor has it generally very long to wait for its prey. An inquisitive ant or small beetle prying incautiously on the treacherous brink of the pitfall where there is no firm foothold, slips, and, struggling to regain its foothold, sends down a miniature avalanche of sand. Instantly the quiescent Ant-lion becomes extremely active, and with its shovel-head jerks up sand as fast as it can, aiming it at the unfortunate ant and generally bringing it tumbling head over heels down to the bottom of the pit. Once arrived at the bottom, there is no chance of escape, for the cruel, hungry jaws of the Ant-lion sink into the body of its victim, which is soon sucked dry. The banquet over, the Ant-lion with a jerk of the head flings the empty skin of its prey out of the pitfall, and once more takes up its position to await another arrival. This larval

Miners, Diggers, and Carpenters.

stage is said to last some considerable time ; but at last the Ant-lion begins to weave a rough cocoon, using a good deal of sand mixed with the silk, as it has not an abundant secretion of the latter. In this cocoon the final transformations take place, and the adult, perfect insect escapes from it, not as a weak-legged, bloated-bodied creature, but as a graceful, slender-bodied, gauzy-winged insect, very much resembling a dragon-fly in appearance, save that the horns or antennæ on its head are clubbed at the tip. There are several species of Ant-lion, and they are to be found in tropical and subtropical countries, and it is interesting to note that they do not all dig pitfalls, some being content to merely hide their soft, ungainly bodies in the sand and to rush out upon their prey.

The larva of the Tiger Beetle also digs a pitfall, which serves the double purpose of trap and dwelling. It is by no means beautiful at this stage of its life, and one would never guess from its appearance that in the perfect state it was destined to be one of the handsomest of our British beetles. It has a long, fat, pale body, with two little processes like blunt hooks on its back, a hard, flat head, and a pair of formidable, sickle-shaped jaws. Its soft body is quite defenceless, while its six spiny legs are very short and of little use for running about, either in search of prey or to escape from foes ; so the Tiger larva must needs hide its body from the view of many hungry foes who would devour it the moment they set eyes on its plump shape, and await in concealment the approach of prey. It is, therefore, for this double purpose that the larva digs a shaft to live in, where it may lurk in safety, and lure its unsuspect-

How Animals Work.

ing victims within reach of its sickle-shaped jaws. With its stumpy legs and large, flat head, it sets to work digging and scraping, heaving the loose earth out of the excavation with its head, which makes a first-rate shovel, until a little tunnel is scooped out, descending vertically at first, and then continued in a horizontal direction. When at last the task of excavating this shaft is completed, the larva mounts to the top of the tunnel, where it rests with its flat head filling the mouth of its den like a trap-door. It is able to rest in this curious position quite comfortably with the aid of its short legs and the two blunt, hooklike processes on its back. Sooner or later some small insect draws close to the entrance of the tunnel, or may even incautiously run on to the large, flat head that fits the opening like a lid. Instantly the head of the Tiger larva goes up with a sudden jerk, and the victim is caught in the strong, curved jaws, dragged below with lightning rapidity, and devoured.

A very expert miner is the Mole Cricket, an insect that is not very often seen in England, but which is all too common in some of the vineyards and highly cultivated lands of France, where it is called the *Courtilière* (Plate VII.). The Mole Cricket is readily distinguished from all other insects by the structure of its front legs, which are very stout, and terminate in a broad, somewhat flattened expansion so deeply notched as to look like an exaggerated replica of the front paw of the mole. The body is large, more or less cylindrical in shape, and bluntly tapers at either end, the greatest width, as in the mole, being across what we may term the shoulders—that is, immediately

Miners, Diggers, and Carpenters.

behind the first pair of legs. The wings are broad, and fold back like a fan, and when expanded are of fairly large size, to permit of lifting the heavy body from the ground. On warm summer evenings the Mole Cricket will sometimes unfurl its wings and indulge in short circular flights, but it does not seem to make as much use of its wings as their size might lead one to expect. Specimens which I had under observation for some time, although allowed plenty of liberty, being placed in a large glass case, never attempted to fly out, but seemed perfectly content to tunnel in the soil, and sometimes to come out in the evening to lick the moisture from the blades of grass which had been sprinkled with water. Only once, when they had been placed in a large, shallow tray, with hardly sufficient earth to cover them, so that I could watch the action of their front legs in digging, did one suddenly take flight; but as it only flew a few yards away, and then, alighting on a flower-bed, began to burrow, it was quickly recaptured.

The insect first drives a vertical shaft down from the surface, kicking out the material which accumulates at the side of this entrance hole. It is wonderful to see with what strength and rapidity the Mole Cricket works, digging away with its powerful front legs, which are so admirably adapted for this work, and with its strong jaws biting through any fibrous roots that may impede its progress. Once the descending shaft has been completed, the Mole Cricket then proceeds to scoop out at its base an oval chamber or living-room. Then numerous horizontal galleries, more or less inclined, and all communicating with the central shaft,

How Animals Work.

are excavated, and from time to time extended in the search for food, which seems to consist chiefly of vegetable matter, though the Mole Cricket is said to be at least partially carnivorous in its habits, devouring any soft-bodied insects or worms that may come in its way. This, however, is a point which I think needs careful reinvestigation, for the unhealthy appearance of any crop growing on land infested by the Mole Cricket seems to point rather to a vegetarian than a carnivorous diet, and I do not think that the mere tunnelling would produce this appearance. In the spring-time of the year "a young man's fancy lightly turns to thoughts of love," and, apparently, so does that of the male Mole Cricket, for on mild April evenings he may be surprised, seated at the entrance to his burrow, singing his slow, vibrant, and monotonous love song, that, oft-repeated, sounds something like the call of the goat-sucker. The female appears to form a special chamber in stiffish, dry soil in which to lay her eggs, which are said to number from two hundred to three hundred. The young emerge about the end of a month from the date of the eggs being deposited, and somewhat closely resemble their parents in appearance, save that no wings are present. According to Monsieur Féburier, three years are required for the complete development of the Mole Cricket, which indicates remarkable longevity in these interesting insects.

Let us now have a look at the Common Mole, which is one of the most expert miners in the animal kingdom. Cordially detested by farmers on account of the hillocks with which it covers their fields and pastures, yet the "little gentleman in velvet" does them many a good

Miners, Diggers, and Carpenters.

turn by devouring vast quantities of wire-worms, leather-jackets, and other noxious, root-devouring insects; and as it is apparently strictly carnivorous in its diet, it probably does far more good than is generally imagined.

Although a very expert miner, in the light of recent careful investigation it would appear that the Mole does not excavate the extraordinarily complicated home beneath the surface of its hillock with which it has been credited by many writers in the past. According to Mr. Lionel E. Adams, who recently communicated to the *Memoirs of the Manchester Literary and Philosophical Society* the result of his investigations, carried on over a period of four years, on the Mole and its fortress, not one of three hundred hillocks examined by him corresponded with that ancient and remarkable drawing of the interior of a molehill that has done duty as an illustration in countless popular works.

The Mole sinks a short shaft below the surface of the ground, at the bottom of which it excavates a more or less globular-shaped chamber, pushing the earth out through the top of the shaft, so that it gradually accumulates in a mound. "When," states Mr. Adams, "this superincumbent earth has reached an inconvenient height another tunnel is made, sometimes from another part of the nest cavity, but more often sideways from the first upward tunnel. All this takes time, and the Mole meanwhile makes fresh runs from the fortress, the seat of its labours, in various directions in search of food. Much of the earth displaced in making these fresh runs falls into the nest cavity, and has to be disposed of in the same way as before. Now the tunnel (or tunnels) leading upwards from the nest cavity

How Animals Work.

becomes longer and longer, winding round under the surface of the growing fortress. The tunnels in the fortress are for two distinct purposes : (a) tunnels to eject earth from the nest cavity and bolt run—these are generally in the shape of a corkscrew ascending from the nest, and often diverging into blind terminals ; (b) tunnels not connected directly with the nest cavity, but traversing the fortress from runs outside it. Through these tunnels the Mole has brought the earth to heap over the nest, and they seldom occur except in boggy land, where the nest is of necessity near the surface of the ground, or even in the centre of the piled-up mound. The nest cavity is roughly spherical, about the size of a large cottage loaf, and quite smooth from constant friction and use. The nest, which completely fills the nest cavity, is a ball of grass or leaves, or a mixture of both. I have found a nest made entirely of dead beech leaves, others entirely of dead oak leaves ; and when it is remembered that this material must all be brought in by the mouth, the amount of labour required can be appreciated. When the nest is taken out bodily, it has to be unwound (if made of grass) to find the centre. There is never a hole apparent ; and not only is the nest always found closed when the young are within, but in all cases, even when old and long deserted. When dry grass is not obtainable, fresh green grass is used, which soon withers and gets dry with the heat of the Mole's body. When a nest containing young is found, it is invariably infested with fleas and mites. Nearly every fortress has a bolt run, by which the Mole can escape when surprised in the nest. This run leads downwards from the bottom of the nest, and

Miners, Diggers, and Carpenters.

then turns upward and out of the fortress by a tunnel of its own, and is very rarely connected with any of the other numerous exits of the fortress. The only fortresses that I have seen without the bolt run have been on marshy land, when such a tunnel would have led to water."

The Badger is another notable miner among animals, frequenting lonely, thickly wooded hillsides and ravines, for it is a shy animal and loves a quiet life. Amidst such pleasant surroundings the Badger excavates its large and roomy underground home, which may have as many as six or eight exits, while the main passage often branches towards its inner extremity. As a rule, only one, or at most two, of these numerous tunnels are used regularly as a means of communication with the outer world, the others being constructed and reserved as emergency outlets by means of which the Badgers can make their escape should danger arise. These additional tunnels also act as ventilating shafts to the great living-room; for the Badger is the most hygienic animal, and keeps its home beautifully clean. It is a powerfully built animal, and has strong forepaws with stout claws and toes admirably adapted for digging, which enable the animal to burrow down into the earth with the most astonishing rapidity. Both front and hind limbs are used in the work of excavation, and dig away with powerful and vigorous strokes. In driving a new tunnel into the earth the Badger is able at first by vigorous kicks of the hind legs to fling the soil backwards out of the entrance; but as it digs deeper and deeper this becomes impossible, and another method has to be adopted. Every now and

How Animals Work.

then the Badger stops in his forward and downward progress to work backwards towards the entrance, sweeping out the accumulation of loose earth with his hind legs as he goes—a simple matter for the Badger, who seems to be able to progress backwards with almost as much ease as forwards. The tunnels are often very extensive and twenty or thirty feet long, their openings above ground being a great distance apart, enabling the Badger to quietly slip away unobserved should danger arise. During the daytime the Badger rests and sleeps peacefully on a clean, thick bed of dry fern within his subterranean but airy chamber, only emerging at nightfall to go in quest of food, which consists chiefly of roots, fruits, snails, worms, and possibly an occasional young rabbit. Normally a harmless, inoffensive animal, the Badger, when provoked or fighting for its life, becomes a most formidable antagonist, for its sharp teeth not only bite severely, but the jaws lock together by a peculiar structure of their junction with the skull, so that the Badger is able to hold on with a vicelike grip. Once plentiful throughout England and Scotland, the Badger has now become comparatively rare, so that only those people who are true lovers of the country, who delight to wander in quiet woodlands and to lie out under the stars at night, may hope now and again to get a glimpse of this most interesting animal.

A small and very expert miner inhabiting Central and North America is the Pouched Rat or Pocket-gopher. It is a quaint little brownish-gray rodent with a rather short, thick tail, and remarkably strong feet, the front paws being armed with long, curved

Miners, Diggers, and Carpenters.

claws. But the distinctive feature, and the one from which the little animal takes its two popular names, is the possession of a pair of large, fur-lined pouches which open outside the cheeks and are literally used as pockets. The Pocket-gopher digs out long tunnels at about a foot below the surface of the ground, in its search for the tender roots of plants, which form its chief food supply. The little animal abounds on the extensive plains of the Mississippi region, where it often does considerable damage. Its favourite nesting site would appear to be deep down in the ground beneath some large tree; here it sinks a deep, winding passage which opens into the large living-chamber some four or five feet below the surface. This living-room is usually carpeted with a bed of soft grasses, while, when it is doing double duty as living-room and nursery, the bed of grasses is mixed with a quantity of fur which the mother Gopher tears from her coat, just as our female wild rabbits do, to make a softer and warmer couch for her offspring. From one side of the main living-room a second passage generally leads to another chamber which serves as a storeroom, and here the Pocket-gopher stores up quantities of roots, nuts, pieces of potato, and other vegetable supplies.

Dr. Merriam, who has made a special study of the habits of this curious and interesting animal, states that in the process of digging its tunnel the Pocket-gopher uses its strong and long upper teeth as a pick to loosen the earth, while "at the same time the fore-feet are kept in active operation, both in digging and in pressing the earth back under the body, and the hind feet are also used in moving it still farther back-

How Animals Work.

wards. When a sufficient quantity has accumulated behind the animal, he immediately turns in the burrow, and by bringing the wrists together under the chin, with the palms of the hands held vertically, forces himself along by the hind feet, pushing the earth out in front. When an opening in the tunnel is reached, the earth is discharged through it, forming a little hillock."

Like the Badger, the Pocket-gopher can run backwards with almost as much speed and ease as it can progress forwards, and Dr. Merriam states that "this method of progression was particularly noticeable when the animal was in his own quarters, where he could follow a runway or an accustomed route. When carrying food to one of his storehouses he rarely turned round, but usually ran backwards to the place of deposit, returning for more, and repeating the operation again and again, the to-and-fro movement suggesting a shuttle on its track."

The same authority gives the following interesting account of the manner in which the Pocket-gopher feeds and fills its remarkable cheek pouches: "After satisfying the immediate demands of hunger, it was his practice to fill one or both cheek pouches. His motions were so swift that it was exceedingly difficult to follow them with sufficient exactness to see just how the operation was performed. If a potato was given him, or a piece too large to go into the pouch, he invariably grasped it between the forepaws and proceeded to pry off a small piece with the large lower incisors. He would then raise himself slightly on his hind legs and hold the fragment between his forepaws while eating—for he usually ate a certain quan-

Miners, Diggers, and Carpenters.

tity before putting any into the pouches. As a rule one pouch is filled at a time, though not always, and the hand of the same side was used to push the food in. The usual course is as follows : A piece of potato, root, or other food is seized between the incisor teeth, and immediately transferred to the forepaws. The piece is then rapidly passed across the face with a sort of wiping motion, which forces it into the open mouth of the pouch. Sometimes a single rapid stroke with one hand is sufficient ; at other times both hands are used, particularly if the piece is large. In such cases the long claws of one hand are used to draw down the lower side of the opening, while the food is poked in with the other. The most remarkable thing connected with the use of the pouches is the way they are emptied. The forefeet are brought back simultaneously along the sides of the head until they reach a point opposite the hinder end of the pouches ; they are then pressed firmly against the head and carried rapidly forward. In this way the contents of the pouches are promptly deposited in front of the animal. Sometimes several strokes are necessary. I have never seen them emptied in any other way."

The Prairie Marmot, more often called from its curious yelping cry the Prairie Dog, lives on the great grassy plains or prairies of North America. It is a most sociable creature, delighting to live in large colonies that may number several hundred individuals ; and really is related to the squirrels, for, save for its yelping cry, there is nothing doglike about it. In some districts where it abounds, one may travel for days together over the flat prairie land, which on all

How Animals Work.

sides is dotted about with the little mounds of earth that mark the entrance to the Prairie Marmot's home, placed at a distance of about six feet apart; while the surface of the ground between the hillocks is marked with well-worn tracks. The burrows are of considerable dimensions, and penetrate to no small depth. They are dug in a sloping direction, at an angle of about forty-five degrees, and after descending some five or six feet take a sudden turn and then rise gradually upwards to open into the main chamber or living-room, which is snugly bedded with a quantity of dry grass, and is frequently provided with a second passage, which probably serves as a bolt run or means of escape should occasion for a hasty exit other than by the main entrance arise. The mound of earth thrown up at the entrance to the main shaft of its home is used by the Prairie Marmot as a watch-tower, where it sits up in a semi-erect attitude on its haunches, keeping up a more or less incessant conversation with its neighbours, and at the same time a watchful eye on the surrounding country. The result is that it is practically impossible to approach one of these colonies unseen, and the moment you are observed a series of shrill yelps from the watchful sentries posted on the hillocks sends the entire population scuttling to earth.

Though shy, the Prairie Marmot is a most inquisitive little beast, so that its disappearance below ground is rarely of lengthy duration. Hardly has one had time to hide beneath some sheltering bush or behind a bunch of reeds ere countless little heads and bright eyes appear at the entrances to the burrows.

Miners, Diggers, and Carpenters.

First one or two of the bolder and probably elder members of the colony cautiously come forth, sniffing the air suspiciously, and, ascending their respective watch-towers, sit up on their haunches and sniff and gaze about in all directions. Satisfied that the danger is passed, they utter a series of reassuring yelps which quickly brings the rest of the population above ground. And then a very pretty and social scene is witnessed, as the sleek, jolly little animals run about, visit each other, or gather into apparently gossiping groups. But the Prairie Marmots are not the only inhabitants of the colony, for the Burrowing Owl—sometimes also called the Coquimbo Owl—and the deadly Rattlesnake take forcible possession of their burrows, having first devoured the rightful inhabitants. When the Burrowing Owl and the Rattlesnake were first observed to frequent the burrows of the Prairie Marmot, it was hastily surmised that all lived together as a “happy family,” but closer and more accurate observation has shown that this is not the case.

The European cousin of the Prairie Marmot, the Alpine Marmot, is also inclined to social habits, and is an expert miner, sinking shafts three or four feet deep, and excavating long galleries which ultimately lead into a large, basin-shaped dwelling chamber. According to one authority on Alpine life, the Marmot frequently has a summer as well as a winter residence, selecting for its summer abode some sunny, grassy oasis surrounded by rocks and chasms, high up amongst the mountains, often at ten thousand feet above the sea level. In such pleasant retreats, comparatively safe from the sudden approach of dangerous neighbours,

How Animals Work.

the Alpine Marmots live together during the warm summer months; then with the approach of winter they descend to lower ground, where they dig out their winter quarters, which are generally more spacious than their summer residence; indeed, the living-room is said sometimes to accommodate a family of fifteen. Quantities of dry grass are brought in and stowed away so as to form not only a food supply, but a deep, soft carpet; and is also used, mixed together with earth and stones, for blocking up the entrances to the chamber, a solidly constructed door being built at a distance of one or two feet from the outer opening. And so through the long, cold winter the Marmots lie snug and warm within their subterranean chambers.

The Hamster, which frequents the cornfields of the temperate regions of Europe, Asia, and America, is, according to the writings of Brehm, the celebrated German naturalist, a very skilful miner. It is a relation of the rats and mice, but much larger, measuring some ten inches in length exclusive of its short tail, which only adds about a couple more inches to its total length. Although of rather prepossessing appearance, the Hamster is not a jolly, amiable little creature like the marmot, but is said to be sullen and ill-tempered. With its strong claws it excavates a nearly perpendicular tunnel which at some distance below the surface alters its course, turning aside and becoming either sloping or horizontal before opening into the fairly spacious living-room. This chamber is excavated at a depth of three to six feet below the surface, and furnished with a deep, soft bed of very fine straw. Besides the entrance tunnel, it generally has two others opening

Miners, Diggers, and Carpenters.

into it : one, reaching to the surface at a considerable distance from the main vertical shaft, is dug out in a sloping manner, and probably acts as a bolt run and easier means of rapid exit ; while the third tunnel leads to the round, oval-shaped storeroom, which is often larger than the living-room. Young Hamsters are said to excavate only one storeroom, while older animals will dig out from three to five. In the autumn both old and young Hamsters become very busy in the fields, collecting quite considerable quantities of grain, with which they fill their storerooms, packing it away as tightly as possible, and sometimes even filling the tunnels leading to the storerooms as well, and finally carefully blocking up with earth the entrance to their precious store that has to last them through the long winter months. At one time it was very generally imagined that the Hamster carefully selected the grain of his harvest, the idea originating in the fact that some of the store chambers were found to be filled with one kind of seed, such as linseed, oats, peas, beans, and corn. But this is not, apparently, due to careful sorting and selection on the part of the Hamster, but rather to the fact that the seeds ripen at different times of the year. Like the marmot, the Hamster with the approach of winter closes the entrances to his snug retreat, spending the cold, drear days of winter in sleep, waking up again about February or March, but not immediately coming above ground, preferring to live within doors for a while, and feeding upon what is left of the grain stored up the previous autumn.

Many of the Crab tribe are expert diggers, and one of the most remarkable in many respects is the

How Animals Work.

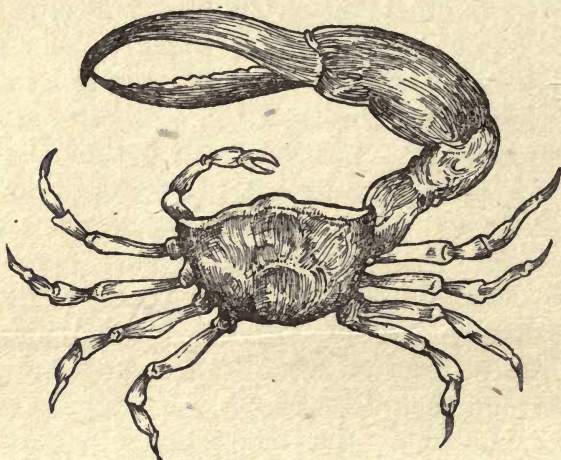
great *Birgos*, or Robber Crab, which lives in a den which it digs for itself in the earth, and is found on islands in the Indo-Pacific seas. To talk of a great crab which lives on land, climbs palm trees, and breaks open cocoa-nuts, sounds as if one were verging strongly towards the region of romance; yet Nature is full of such surprises, outrivalling the strangest dreams of the imagination. The *Birgos* is such a crab, although its ability to climb far up a tree seems rather doubtful; and of its curious habits Darwin, in his account of his voyage round the world in the *Beagle*, gives the following interesting description: "I have before alluded to a crab which lives on the cocoa-nut; it is very common on all parts of the dry land, and grows to a monstrous size; it is closely allied or identical with the *Birgos latro*. The front pair of legs terminate in very strong and heavy pincers, and the last pair are fitted with others weaker and much narrower. It would at first be thought quite impossible for a crab to open a strong cocoa-nut covered with the husk; but Mr. Liesk assures me that he has repeatedly seen this effected. The crab begins by tearing the husk, fibre by fibre, and always from that end under which the three eye-holes are situated; when this is completed, the crab commences hammering with its heavy claws on one of the eye-holes till an opening is made. Then turning round its body, by the aid of its posterior and narrow pair of pincers, it extracts the white albuminous substance. I think this is as curious a case of instinct as ever I heard of, and likewise of adaptation in structure between two objects apparently so remote from each other in the scheme of nature as a crab and a cocoa-nut tree.

Miners, Diggers, and Carpenters.

The *Birgos* is diurnal in its habits ; but every night it is said to pay a visit to the sea, no doubt for the purpose of moistening its branchiæ. The young are likewise hatched, and live for some time, on the coast. These crabs inhabit deep burrows, which they hollow out beneath the roots of trees, and where they accumulate surprising quantities of the picked fibres of the cocoa-nut husk, on which they rest as on a bed. The Malays sometimes take advantage of this, and collect the fibrous mass to use as junk. These crabs are very good to eat ; moreover, under the tail of the larger ones there is a great mass of fat, which, when melted, sometimes yields as much as a quart bottle full of limpid oil. It has been stated by some authors that the *Birgos* crawls up the cocoa-nut trees for the purpose of stealing the nuts. I very much doubt the possibility of this ; but with the *Pandanus* the task would be very much easier. I was told by Mr. Liesk that on these islands the *Birgos* lives only on the nuts which have fallen to the ground. Captain Moresby informs me that this crab inhabits the Chagos and Seychelle groups, but not the neighbouring Maldiva Archipelago. It formerly abounded at Mauritius, but only a few small ones are now found there. In the Pacific, this species, or one with closely allied habits, is said to inhabit a single coral island north of the Society group. To show the wonderful strength of the front pair of pincers, I may mention that Captain Moresby confined one in a strong tin box which had held biscuits, the lid being secured with wire ; but the crab turned down the edges and escaped. In turning down the edges it actually punched many small holes quite through the tin ! ”

How Animals Work.

The Calling Crabs of tropical and subtropical seashores are most comical little diggers, the male crab presenting a most laughable appearance, for one of his claws is developed to an immense size, and brightly coloured, while the other is quite small. As he scuttles over the mud flats left dry by the receding tide, the little crab flourishes aloft his great claw in a most absurd manner, as if he were violently beckoning you to advance,



The Calling Crab.

or challenging you to mortal combat ; but really, he is not particularly valiant, and scuttles off to his den in a great hurry if alarmed. He excavates a burrow about a foot in depth, digging away with much persistence and vigour, and the operation is both amusing and interesting to watch. The crab scrapes away with his claws until he has collected a little heap of the moist, muddy sand, which he then grasps with some of the legs on one side of his body, and ambles off to a distance with

Miners, Diggers, and Carpenters.

his burden. Having deposited the mass, he pauses for a moment, rolling his eyes, which are mounted on long, slender stalks, round in the most comical fashion, and then hurriedly returns to his digging. The exact use of the immense claw of the male Calling Crab does not seem to be known ; it is supposed that he stops the mouth of his burrow with it when he and the female are safe inside. It certainly is used to some extent in combats with other males ; while Professor Alcock, from observations made in the Indian Ocean, believes that it is used for exciting the admiration of the female in courtship, as the huge claw is bright red in colour, and he has seen the male brandish it about before the female, as if displaying to the fullest its florid beauty. In the female both claws are quite small.

One of the most remarkable diggers in the animal world is a native of that wonderful country, Australia ; it is called the Duck-billed Platypus, or *Ornithorhynchus*. At the first glance one would hardly imagine that this curious-looking animal, with its flat, webbed feet and broad bill, so like the feet and beak of a duck, would be an expert digger, yet such is really the case, the animal making burrows and tunnels of considerable length and complexity. The broad web which extends beyond the claws falls back, when the animal is digging, in such a way as not to impede the operation in the least, and materially aids the Duckbill in flinging back the earth which its claws have scraped away. The Duckbill is essentially an aquatic animal, always making its home in the bank of some stream, often showing a marked preference for those wider and quieter parts of the river which resemble large pools. Here in the bank,

How Animals Work.

at a point well concealed by overhanging plants, the Duckbill digs a long and often very winding tunnel, which generally passes in a slightly upward direction until it opens into the subterranean nest, which is a somewhat oval-shaped chamber, and generally carpeted with a plentiful supply of dry weeds and grasses. There is a second opening in this chamber, which leads to a tunnel that descends and has its opening well beneath the surface of the water, so that the Duckbill, if alarmed, can enter or leave its nest unobserved. The many turns and twists of the upper gallery are probably not altogether intentional, but are rather due to various obstacles such as roots and stones, for no two burrows ever have exactly similar curves and windings.

The graceful Sand Martin that reaches our shores from distant Africa, a slender-winged messenger carrying the promise of the coming of spring, though so small and delicate a bird, is yet a wonderfully expert miner, digging in an incredibly short time a shaft of relatively considerable dimensions in the face of the vertical sand cliffs that it always frequents. Working away with its short, delicate bill and slender feet, the Sand Martin scrapes away at the sand and gradually digs out a more or less cylindrical, slightly upward-sloping burrow, which may extend inwards for a distance of from two to four feet. The end of this burrow is slightly enlarged to form the nesting chamber, in which a soft, loose nest is built of straws, lined with feathers. The indefatigable way in which the birds labour at their task is truly wonderful, and one would think that their little feet and beaks would be worn to shreds in the process. They do not generally begin their

Miners, Diggers, and Carpenters.

labour of excavation much before the middle of May, yet they go at their work with such incessant and right good will that by the end of the month the tunnel is completed, the nest built, and in it repose four or six beautiful, pure white eggs, with shells so thin and clear that, when freshly laid, the ruddy yolk within shines through, giving them an exquisite golden-pinkish hue. The Sand Martin is essentially a sociable bird, and generally from twenty or thirty to even a hundred pairs will nest in close proximity to each other, so that the vertical face of the sand cliff is quite honeycombed with their excavations.

That glorious feathered jewel, the Kingfisher, that Tennyson called the "sea-blue bird of March," is another expert among birds in the art of mining. Nesting generally begins about the second week in May, though in some seasons it is much earlier. The Kingfisher generally selects for its nesting site a steep, vertical bank by the stream side, up which none of its four-footed carnivorous foes can scramble. Here, at a convenient distance above the stream, it sets to work with its sharp, strong beak, and begins to bore a round hole of just sufficient diameter to admit its body. Digging slightly upwards, the Kingfisher continues tunnelling into the bank for a distance of some two to three feet, the gallery terminating in a smooth, roundish cavity which forms the nesting chamber. The Kingfisher does not seem to work quite so rapidly as the Sand Martin, so that the work of digging the tunnel takes a proportionately longer time. Should a stone be met with during the work of excavating, it will, if possible, be bodily removed by the bird ; but if of too great a size,

How Animals Work.

then the tunnel will be diverted to one side of it ; while, should too many obstructions be found, the bird will abandon the half-formed tunnel, and start a fresh boring at another spot. The nest within the gallery is indeed a strange and malodorous one, consisting of a few fish bones sprinkled on the bare earth floor of the chamber, which increase in number as time goes on.

The Puffin is also a true burrower, but is by no means so anxious voluntarily to undertake the task of excavation as are the Sand Martin and the Kingfisher ; indeed, where possible, it will always take possession of an already existing tunnel and adapt it to meet its requirements. A rabbit's burrow is eagerly annexed ; and although poor bunny may vigorously protest at this undesirable intrusion upon her domain, she is generally compelled to beat an ignominious retreat before the scolding wrath and fierce onslaught of the Puffin's powerful beak. Where, however, such easy lodgment is not to be obtained, the Puffin makes the best of the circumstances, and sets honestly to work on its own account to excavate a burrow. The male bird is chiefly occupied in the task, though he receives a certain amount of help from his mate, and becomes quite engrossed in his labours. With his strong bill he digs out a tunnel about three feet in length, which is seldom straight but takes a more or less curved form, and is generally furnished with a second entrance. At the end of the burrow no nest is formed, the Puffin laying its large, whitish egg on the bare earth.

The Green Woodpecker, the Yaffle or Rain-bird—to give it its dear old country names—is a notorious excavator in wood, so that he really more deserves the

Miners, Diggers, and Carpenters.

title of carpenter than miner, although it is a dark tunnel that he drives into the tree. His cheery, laughing cry is a familiar sound to most lovers of our woodlands, especially in changeable weather, and it is his ringing call heard so constantly when rain is approaching that has gained for him his two old country names. In form he is wonderfully adapted to his method of life : his beak is a veritable straight, strong pickaxe mounted on a suitably large and lengthy head, while his legs are set far back, so as to give ample swing to the pickaxe, and the short, strong, spiky tail gives additional support and grip. It is not surprising, therefore, to find that the Woodpecker is able to drive the tunnel leading to its nest deep into the sound heart of a tree ; while with the greatest ease its powerful beak is able to split and tear the dead wood and bark in the search for the insects upon which the bird feeds. It is generally somewhere about the middle of April that the Woodpecker begins to bore a hole for its nest. First a neat round hole is drilled horizontally into the middle of the tree trunk or limb, the opening being about two and a half inches in diameter. This completed, the Woodpecker begins to drive its shaft perpendicularly downwards for a depth of about two feet, where it makes a slightly enlarged chamber, and here the hen bird lays her glossy, pure white eggs on the bare wood, no attempt whatever being made to line the interior of the nest chamber. Although the Woodpecker sometimes takes advantage of rotten wood in a tree for boring its hole, such aid is by no means necessary ; and while the bird undoubtedly does good service in hunting out and devouring large numbers of wood-boring insects, it

How Animals Work.

nevertheless does a certain amount of harm to growing timber, and therefore is not always looked upon with much friendliness by the forester. Besides the Yaffle, we have in our English woodlands two equally expert bird carpenters—namely, the Great Spotted or Pied Woodpecker and the Lesser Spotted Woodpecker, both smaller than the Yaffle, and excavating similar though smaller nesting holes in the branches of the trees. The Great Spotted Woodpecker in the spring-time often attracts attention by a remarkable drumming sound, almost like the roll of a kettledrum, which it produces with its bill on some dead branch of a tree. This peculiar drumming performance probably is not for the purpose of scaring insects out of the crevices in the branch by its vibration, but rather is a form of display on the part of the male to attract the attention of the hen bird.

CHAPTER XI.

SOME BIRD ARCHITECTS.

FOR sagacity and skill in the selection of suitable material, and in the design and construction of their nests, the birds stand in the very front rank of animal craftsmanship. Although constructed as but a temporary home for the safe-keeping of the eggs and young, yet in its highest development the nest of a bird is a truly wonderful piece of work—a thing to marvel at when we remember that its graceful proportions and perfection of construction have been attained without the aid of any special tools or building appliances save the slender feet and legs, the bill, and the soft breast of the parent birds. Its building has been a labour of love, and in its perfect completion it is the outward symbol of that absolute and passionate parental devotion that is so highly developed among birds. They are such joyous, beautiful little architects, going about their work so blithely, and later, when the nest is full of hungry fledglings, doing such invaluable service to mankind in hunting down innumerable plant-destroying insects which form the staple diet of their nestlings, that they deserve all the care and protection we can possibly give to them. Yet thousands of innocent birds are killed by farmers and agriculturists, the very people who most benefit by

How Animals Work.

their services in holding in check the insects that would otherwise devour their crops, but who are too steeped in self-satisfied ignorance and tradition either to take the trouble to observe accurately and dispassionately for themselves, or to give honest credence to the advice or warnings of those who have studied the habits of their victims ; while the so-called amateur " sportsman " too often seems to consider " sport " as standing for the slaying of every bird that crosses his path. Women, too, help in this senseless slaughter, and are responsible for the fast-approaching extinction of many beautiful birds. The present ruthless and wanton slaughter of birds for the bedecking of women's hats and garments is a disgraceful, a shameful, and revolting trade—one which, if left unchecked, will eventually bring disaster to many countries, by removing the natural balance of bird and insect life, so that the latter will increase in such numbers as to become a serious menace to all agricultural labour, and may even cause the total destruction of our food crops. It is a danger which has got to be faced, squarely and honestly, and is one which no half-hearted legislation can avert.

Have you ever considered the nest of a bird in its full significance, not merely as a jumble of twigs and moss and hair brought haphazard together, for that is a false idea altogether, but in its true light—as a perfect piece of workmanship wrought with loving care and labour ? If you have once given it a moment's serious thought, I am sure you could not have helped being impressed by its beauty and ingenuity, and perhaps wished that you might learn more of the ways of these feathered architects, and, best of all, that they

Some Bird Architects.

might be sheltered from harm and permitted to carry out their innocent, useful labours in peace. Ruskin has left us a delightful account of the wonder and admiration with which he was filled on being shown a particularly beautiful nest. "The other day," he writes, "I was calling on the ornithologist whose collection of birds is, I suppose, altogether unrivalled in Europe (at once a monument of unwearied love of science, and an example, in its treatment, of the most delicate and patient art)—Mr. Gould. He showed me the nest of a common English bird—a nest which, notwithstanding his knowledge of the dexterous building of birds in all the world, was not without interest even to him, and was altogether amazing and delightful to me. It was a Bullfinch's nest, which had been set in the fork of a sapling tree, where it needed an extended foundation. And the bird had built this first story of her nest with withered stalks of clematis blossom, and with nothing else. These twigs it had interwoven lightly, leaving the branched heads all at the outside, producing an intricate Gothic boss of extreme grace and quaintness, apparently arranged both with triumphal pleasure in the art of basket-making, and with definite purpose of ornamental form. I fear there is no occasion to tell you that the bird had no purpose of the kind. I say I *fear* this, because I would much rather have to undeceive you in attributing too much intellect to the lower animals than too little. The bird has exactly the degree of emotion, the extent of science, and the command of art which are necessary for its happiness; it had felt the clematis twigs to be lighter and tougher than any others within its reach, and probably found the forked branches of them con-

How Animals Work.

venient for reticulation. It had naturally placed these outside, because it wanted a smooth surface for the bottom of its nest ; and the beauty of the result was much more dependent on the blossoms than the bird. Nevertheless, I am sure that if you had seen the nest—much more, if you had stood beside the architect at work upon it—you would have greatly desired to express your admiration to her.” One cannot help feeling that, had Ruskin been able to spend more time in the observation of the many treasures of bird architecture which Mr. Gould’s collection contained, and could have been converted from his bitter antagonism to the truth of evolution, he might have given to the world a *Seven Lamps* of Bird Architecture.

There is such a wealth of material to select from that it becomes very difficult to decide which examples of bird architecture shall be chosen as most effective for the present necessarily brief description of bird craftsmanship. I am a great believer in the importance of, if possible, seeing and proving things for yourself ; therefore I shall devote the space at my command to a description of some of our familiar British nests, and a few of those tropical nests examples of which are generally to be seen in any good museum collection. Let us take as our first example the nest of the Song Thrush, which may be found in almost any quiet orchard or country hedgerow (Plate XII.). Indeed, if we had the good fortune to spend our childhood days in the country, it is probably the first nest with which we became familiar. It is quite early in the year that the Thrush begins to search for a nesting site, and it is no

PLATE XII.



THE NEST OF THE SONG THRUSH.

The Song Thrush is not only an expert weaver, but a clever mason, for she lines her nest with cement.

Some Bird Architects.

uncommon occurrence in sheltered shrubberies to find both nest and eggs by the end of February. Although the bird will build its nest almost anywhere in bushes, trees, and hedgerows, it nevertheless devotes some time to the selection of the site, and I have seen on occasion bitter fights take place between rivals for a coveted spot. Once the position has been settled the building is commenced, and is carried forward with wonderful precision, skill, and rapidity. All day long the work goes on, the patient little architect bringing moss and slender twigs, dry grasses, and similar material, which is skilfully woven into the familiar ample cup-shaped nest, and reinforced with an ample supply of mud well worked into the foundations. Then comes the lining of the nest, which shows the Thrush not only as a skilful weaver, but as an expert plasterer and mason; for the bird now makes a cement composed of an admixture of mud, rotten wood, and cow dung in varying proportions, and with this coats the whole of the interior of the nest, the walls of which become converted into a perfectly smooth, damp-proof, cup-shaped receptacle for the safe housing of the precious eggs. Sad to say, this expert masonry on the part of the parent Thrush sometimes leads to disaster, an unusually prolonged downpour of heavy rain filling the nest and drowning the nestlings.

The art of nest-building is an acquired habit, and the evolution from the simplest form to the most complex type of construction can be traced step by step in the selection of site, materials, and shape of the completed nest. "That the earliest birds were arboreal in their habits there can be little room for doubt, and

How Animals Work.

we may assume that they brooded their eggs in the holes of trees or in the stumps of decaying tree-ferns, or amid the crowns of evergreen oaks and similar trees, which had, with the appearance of the first bird—Archæopteryx—already come into existence. With the gradual spread of the race some became denizens of the open country, and these would probably at first have deposited their eggs on the bare ground without making any special preparations for their safety or protection. Two new selective factors would now come into operation—one tending to eliminate all eggs which were not protectively coloured, and the other all such as suffered from contact with cold or moist earth. It is not difficult to imagine that, sooner or later, more or fewer of the birds nesting in such sites would hit upon the plan of collecting bits of grass and sticks or small stones into a small heap whereon to lay their eggs, prompted not so much by any conscious desire to protect the eggs from injury as to keep warm and dry when sitting where the ground was damp. Only those birds which had sufficient intelligence to adopt this expedient would rear offspring, and this offspring would probably inherit the same instinct. Thus were the first nests built. The habit of building a nest once fixed, wherever the eggs were laid some receptacle would be first constructed, and thus the way was prepared for those birds which, to avoid enemies, took to laying their eggs amid the branches of shrubs and trees. The possibility that the earliest nesting sites were holes in trees receives some little support from the fact that many birds still retain this habit, and lay white eggs. As the primitive arboreal bird left the forest regions, some sought the dark

Some Bird Architects.

recesses of caves or the deserted burrows of other animals."*

The primitive type of nest first built amidst the branches of the trees was probably a mere rough collection of twigs more or less loosely woven together, and because it suffices its intended purpose we find it still the typical nest of many birds, such as the Pigeons, whose nest is the merest latticework of twigs, the Crows, and the Herons. The Hawfinch and the Bullfinch have carried the art a step further, for they have added to the loosely arranged platform of twigs an inner neatly woven cup of fine hair and slender rootlets. From such crude beginnings we can trace the advancement of the craft in a series of infinite gradations in the gradual refinement of selection of building materials and work of construction and design. Our Thrush's nest, for instance, represents one of the earlier phases, where mud, in addition to grasses and rootlets, has been employed, and probably gave origin to the ultimate exclusive use of mud as building material for the nest, as is the habit with some birds; while, on the other hand, we can trace the abandonment of the admixture of mud, and the rejection of twigs and all coarser materials, until we arrive at cup or dome shaped structures woven of only the very finest hair, wool, and rootlets.

The little Stonechat we may take as our first example of a bird not using any mud in the construction of its nest. It is a bird that haunts open heaths and commons, where furze bushes and a plentiful growth of heather luxuriate. Here, about the middle of March or a little later, according to the climatic conditions of

* W. P. Pycraft, *A History of Birds*.

How Animals Work.

the season, the Stonechat begins to build its nest, choosing a well-concealed site amidst thick heather or dense furze, on or very close to the ground. Only the softest dry grass and moss are collected and rather loosely woven together to form the nest, and generally a little rabbit's fur is added as a soft lining on which the precious eggs are laid. It is rather a frail little nest, but is very dainty in its workmanship. The Meadow Pipit or Titlark's nest is often built among tall grass tussocks and heather, very often where there is a slight hollow in the ground, and is composed entirely of dry grasses, the finest being used for lining. The hen bird has a little trick of suddenly rising from the grass and half flying, half fluttering for a few yards and then sinking down, only to rise again at your approach to flutter a few yards further. It is a clever device on her part to attract your attention, and to draw you away from her precious nest and eggs. More elaborate in its construction is the nest of the Goldfinch. In this case the nesting site is generally from six to even twenty feet above the ground, in a small fork among the outer boughs or twigs of some large tree, or resting upon a broad thick branch ; but sometimes the bird will elect to build in a thorn bush or tall hedge, or even in the midst of a growth of ivy covering a tree trunk. It is about the beginning or middle of May that the Goldfinch starts its building operations. Moss, wool, hair, cobwebs, and similar soft materials are collected together, and with these a most beautifully compact nest is built.

The Chaffinch is a most artistic nest-builder. About the end of March the little architect begins to seek a

Some Bird Architects.

favourable nesting site, about which it does not seem to be very particular, for it will build in almost any situation—in a hedge, among the branches of old mossy apple trees, in a bramble patch, the tall laurels of a quiet shrubbery, or under the sheltering growth of an ivy-mantled wall. But no matter the situation ; an enormous amount of skill and loving care is bestowed upon the construction of the nest, which is a most perfect piece of bird architecture in its completion. Green moss, gray down, soft wool, cobwebs, hair, and feathers go to its making ; the whole being woven into a close, compact, and shapely cup of uniform texture and singular beauty. Nor does this always complete the labours of the little feathered architect, for if they are available in sufficient quantity, the Chaffinch will almost invariably bedeck the whole of the outside of its nest with gray and various coloured lichens. It is a most beautiful and decorative piece of work, and when, as is often the case, the nest has been built in the fork of an old moss and lichen covered apple tree, this outer dressing of lichens helps to a wonderful degree to further conceal the nest. But I am afraid we cannot safely credit the little Chaffinch with a really deliberate or definite attempt at imitations of the surroundings of the nest, for the bird will often do exactly the same thing when it has built its nest in the middle of a furze bush or a thorn hedge, with the result that the nest is made more conspicuous.

I think that quite the most beautiful and remarkable nest built by any British bird is the large, oval, lichen-covered nest of the Long-tailed Tit. Though the extreme length of its tail gives it an advantage in

How Animals Work.

actual length over a number of larger species, the little Long-tailed Titmouse, next to the Goldcrest, is the smallest British bird. In spite of its delicacy of form, it is a hardy, active, restless little creature, and is very sociable and fearless. The little bird nests early in the year, the young being often hatched before the end of April. It will build its nest in the most varied situations, though one of its favourite sites is among thick thorns or brambles, or the midst of a furze bush; sometimes a holly bush or a dense growth of ivy attracts it, or it will build in the fork of a willow, ash, or some other tree.

The actual building operations generally start with the weaving of the bottom of the nest, the birds building upwards, and using chiefly moss and wool held together by spiders' webs in the construction of the outer walls, while the interior is lined with feathers. In the first stages of its construction the nest looks very much like the half-finished nest of a Chaffinch. The amount of material used, and the labour of collecting and weaving it together, are prodigious, the cock and the hen bird taking an equal share in the task. Gradually the sides of the nest are built up, the little feathered architects at first working perfectly evenly at the mossy walls; but as the work progresses one side of the nest begins to rise more rapidly than the other, and this side is continued over the top, forming the dome of the nest, beneath which is the little entrance hole. Then the exterior is incrustated all over with gray tree lichens, and this exquisite piece of work is completed. When built in the midst of a thorn bush, several of the supporting branches are

Some Bird Architects.

often included within the framework of the nest, giving it additional strength. This is an interesting feature, inasmuch as from it probably gradually evolved the tree pensive or hanging nest that is built by many birds. The lining, composed of feathers, must cost the little Long-tailed Tits an enormous amount of labour; for Macgillivray states that he found in one of their nests no less than 2,379 feathers, which had originally formed part of the plumage of the Pheasant, Rook, Partridge, and Wood Pigeon.

Feathers and down are eagerly sought by many birds to form a lining, and in some cases to be built into the main structure of the nest, the most charming and artistic results often being obtained. The Lesser Redpole often uses feathers most effectively. It builds a small and very beautiful nest, delicately and neatly constructed; the framework generally consists of woven twigs, grass stems, and moss, the little cup being smoothly lined with cotton-grass, down, and feathers. In the nest figured in Plate XIII. we have a particularly beautiful example, the birds having used the stems of the wild clematis, which they had obtained from a hedge near their nesting site, for the outer wall; and from the border of the mill-pool near by, frequented by a pair of swans, they had obtained a supply of swan's-down, with which the cup was not only lined, but its edge adorned by a most beautiful fringe, only the tips of the delicate white feathers showing, and curving gracefully inwards so as to partially screen the eggs from view.

A truly remarkable nest is built by the Reed Warbler (Plate XIV.), and is of particular interest because in its

How Animals Work.

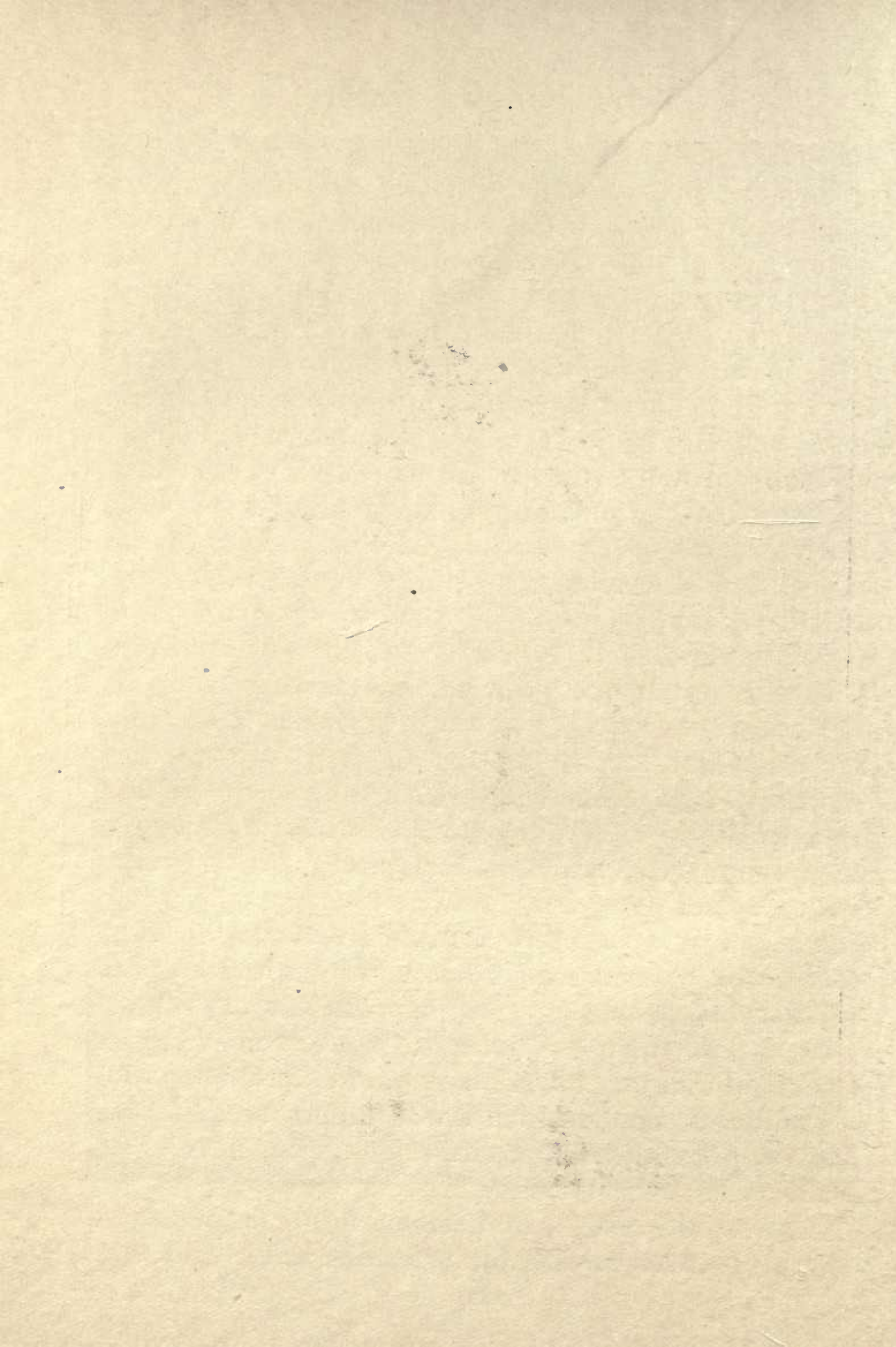
construction it is an example of a nest which may be said to occupy an intermediate position between nests like that of the Long-tailed Tit, which is interwoven between the supporting branches, and the true suspended nests shortly to be described. It is generally slung above the surface of a quiet pool, in the middle of a reed-bed. The material used by the Reed Warbler in the construction of the nest consists of long grass, the seed-heads of reeds, and a little cottony wool and moss. The grass stems, which generally form the foundation, are wound horizontally round about the stems of three or four tall reeds, so that they actually pass right through and form parts of the sides of the nest, which, as the work of weaving proceeds, assumes a somewhat conical shape, and is about five or six inches in depth when completed. Into the interstices is worked the cottony material from the catkins of the willows and poplars, while the cavity within, which is some three inches in depth, is lined with the finest grasses and some hairs. So firmly yet elastically is this nest bound to the supporting reeds, and so great is its depth, that, no matter how the reeds may sway and bend in the wind, the eggs will not roll out, and the little sitting mother bird rests safely brooding them within the rocking cradle.

For the most striking examples of pensile or hanging nests we shall have to seek the work of birds inhabiting other lands, but among our British birds we have at least one good example in the nest of the Goldcrest, or, to give it its full title, the Golden-crested Wren, the smallest of our native birds. The wee bird selects for its building materials the softest moss and wool it



PLATE XIII.—THE NEST OF THE LESSER REDPOLE.

An exquisite piece of workmanship.



Some Bird Architects.

can find, and these are woven together with the aid of spiders' webs and long grasses, the whole dainty structure being suspended hammock fashion from the under side of the slender twigs at the end of the branch of some coniferous tree, such as a larch, fir, yew, or cedar. The frail hammock cradle is then lined with a few small feathers.

The Long-tailed Tit is by no means our only British bird architect that affects a dome-shaped structure; the little Willow Wren, whose sweet song captivated the heart of the American naturalist Burroughs—who declared it to be the sweetest of British songsters—is skilled in the construction of the dome-shaped nest, though its work is not so fine or so complex as that of the Long-tailed Tit. The graceful little Willow Wren is not, as its popular name might lead us to suppose, really any near relative of the true Wren. It haunts the alders and tangled growths of sedges fringing any quiet wandering moorland stream, and there its soft sweet song may be heard from about the end of March until summer has far advanced. Its nest is generally built very low down, if not actually touching the ground, and is generally so well concealed from view as to make the watching of the actual building operations a somewhat difficult if not altogether impossible task. Dried grasses, dead leaves, fragments of last season's bracken fern and moss, are collected and woven into a beautiful dome-shaped nest, with a large opening at the side; and the interior finally receives a soft, thick bedding of feathers.

The Chiff-chaff builds a somewhat similar dome-shaped nest, chiefly of dead leaves, moss, and dry

How Animals Work.

grasses; but it can generally be distinguished from that of the Willow Wren by its much larger entrance, and by its generally being built well off the ground in brambles and in mixed herbage. The true Wren is another feathered architect which delights in constructing a dome nest. Very varied are the sites selected by the little bird for the building of its nest—such as in the midst of a dense growth of ivy, an old creeper-clad wall or tree, in the shelter of a hole in a thatched roof, under the shelter of the overhanging turf and roots near the top of a steep bank, or in a tangle of brambles and dead bracken fern in an open woodland glade. When the latter situation is selected, the nest is by no means easily detected; for the bird will utilize the dead stems of the ferns as a natural framework, weaving the branches together most cleverly. The nest is a fairly compact structure, round or oval in shape, with the entrance hole in the side, moss and dead leaves being used chiefly in its construction; while feathers, fern, moss, and pieces of dry leaves are all worked up together to form a soft lining.

There is one particular point of interest about the Wren on the exact significance of which I believe ornithologists are still by no means agreed, and that is its curious habit of partially building several nests before constructing the one intended for the reception and incubation of the eggs. They certainly do not appear to be ordinary nests that have been abandoned half-way in their construction, for they are very rarely used as the foundation of a true nest, but are considered by some authorities to be nest-like structures built for the purpose of courtship, like the wonderful

Some Bird Architects.

decorated bowers and runs of the Australian Bower-birds.

Of British birds which have retained the primitive architecture of the first platform nest built amidst the branches of the trees we may take as typical examples the Wood Pigeon, Heron, and Crows; while the Magpie shows a considerable advance in the use of sticks and clay. The Wood Pigeon, or Ring Dove, makes the merest apology for a nest: it consists of a loose, flimsy platform of sticks scantily lined with a few finer twigs, and upon the primitive platform cradle the bird lays its two glossy, pure white eggs. The nest of the Turtle Dove is very similar, and built in much the same situations, though the bird shows a preference for tall bushes and hedges at a height of six to ten feet from the ground; while the Wood Pigeon will build almost anywhere in the branches of trees, tall shrubs, and bushes. Now the white eggs of the Wood Pigeon and the Turtle Dove are most striking and deeply interesting exceptions to the practically general rule among eggs laid in open nests in trees and bushes, or on the bare ground; for these are always tinted all over and spotted, streaked or blotched with deeper colours, so as to render them less conspicuous, and consequently less likely to catch the eye of egg-destroying animals. It is only amongst birds which nest in holes and excavated chambers that pure white eggs are the rule. What, then, is the meaning of this apparently flagrant defiance of a natural protective law on the part of the Wood Pigeon and the Turtle Dove? They are certainly not imbued with greater courage or provided with more effective weapons of defence than other nest-building birds.

How Animals Work.

No ; we must dip a little deeper below the surface of obvious facts if we are to find the true explanation.

First, what of the habits of the nearest relations of the Wood Pigeon and the Turtle Dove ? Well, now, their nearest relations are the Stock Dove and the Rock Dove, and both these birds breed in holes, and also lay the orthodox pure white eggs typical of all such nesting sites ; in fact, the Stock Dove takes its popular name from the habit of nesting in some large, roomy hole in a tree. Where suitable trees are scarce, the Stock Dove will utilize a deserted rabbit hole, or even lay its eggs beneath the shelter of a dense furze bush ; while occasionally it is known to occupy a squirrel's nest or " drey," or an old Magpie's nest. From these facts it is not a difficult matter to arrive at a solution of the problem. The ancestors of the Wood Pigeon and the Turtle Dove were, like the Stock and Rock Doves of to-day, birds that nested in holes and laid white eggs, and that, scientifically speaking, at no very distant date. For some reason, some thousands of years back the Wood Pigeons and Turtle Doves gave up nesting in holes and took to an arboreal life. The period of time, though long from a purely human point of view, has not been sufficient for these Pigeons to acquire the skill in the construction of the nest, or the colouring of the egg to render it less conspicuous, which is the habit of all true nest-building birds, and therefore they may be said to be in a state of transition ; their primitive nests, though extremely poor cradles for an open situation in trees and tall bushes, would yet perfectly suffice as a mere flooring or lining for a snug and well-protected hole, when the white eggs would be safely hidden

Some Bird Architects.

from view. This point is confirmed by the fact that the Rock Dove does make an almost exactly similar twig nest in such a situation. We may safely suppose that in ages to come the Wood Pigeon and Turtle Dove will gradually acquire the necessary skill to construct the kind of nest which Nature demands of all nest-building birds that build in the more open situations they have chosen for the safety of their offspring, and that their eggs will also become coloured, and therefore less conspicuous objects.

As a matter of fact, there is a great deal to be learned of the amount of progress, or rather I should perhaps say divergence from the ancestral type, by the careful examination of the colour of the egg in conjunction with the structure and shape of the nest in which it is deposited, and the nesting site. Probably the eggs of all birds were first of all white and unspotted, like those of their reptile ancestors; but only those birds which have continued to nest in deep safe holes have been able to continue laying such conspicuous eggs—those which breed in more exposed situations having of necessity developed on their eggs patterns of colour which in the course of time have become more or less imitative of the colouring of their surroundings in proportion to the greater or lesser need for this kind of protection, according to the character of the particular nesting site selected.

The Crow's nest shows a considerable advance in the art of nest construction over that of the Wood Pigeon, though of rather rough, untidy appearance. The foundation is of sticks roughly tangled together, the character of the workmanship varying among the

How Animals Work.

different members of the Crow tribe—some, like the Rooks, using sappy twigs for the cups of the nest, which they line with dry grass, moss, and leaves ; others, like the Carrion Crow, using wool, tufts of hair, and roots for the lining. As the same nest is often used again and again, year after year, repairs and additions being made to it annually, the structure gradually assumes considerable proportions, and contains a surprising amount of material.

The Magpie builds a large and conspicuous nest at almost any height and in varied situations, being equally at home in the topmost branches of a tall elm or beech, or amidst the prickly embrace of a dwarf thorn bush. The nest is a solid structure of sticks and clay, basin-shaped, and roofed over with a lighter dome of twigs. First of all the bird collects a quantity of sticks, and interlaces them to form the base and outer framework of its nest, and this is succeeded by a substantial layer of clay and mud. Within this basin a double lining of fine twigs, rootlets, and grass forms a springy bed for the eggs to rest upon, and also a porous one, effectually preventing the nest becoming water-logged during a heavy downpour of rain, as so often happens to the nest of the Thrush. Then for the construction of the dome of the nest the Magpie selects long, tough twigs, which it interlaces with considerable skill, so that they form an open network, which, though it does not entirely conceal the interior of the nest, nevertheless constitutes a stout fortification against foes on egg-stealing intent, only a small hole at the side, just sufficient for the bird to slip in and out, being left. By this means the large and generally conspicuous nest is pretty effectively pro-

Some Bird Architects.

tected from the depredations of Carrion Crows and other foes.

The Heron, with its long, stilt-like legs and long neck, does not seem to be of a comfortable build for nesting in trees, and indeed in many countries it often nests on the ground in lonely marshland ; while in Britain it sometimes builds on the bare ground or cliffs and the top of old ruins, though a tree-top is its more usual nesting site. Its antics during the process of nest-building in the early spring amidst the naked branches of some flat-crowned oak are anything but dignified, and offer a mirth-provoking spectacle. The nest is very large and rather flat in form, the cup being a very shallow one, composed of sticks, lined with twigs, roots, and occasionally a little dried grass. It is a primitive affair, but generally sees several years' service ere it is abandoned, fresh material being added by way of repair each spring.

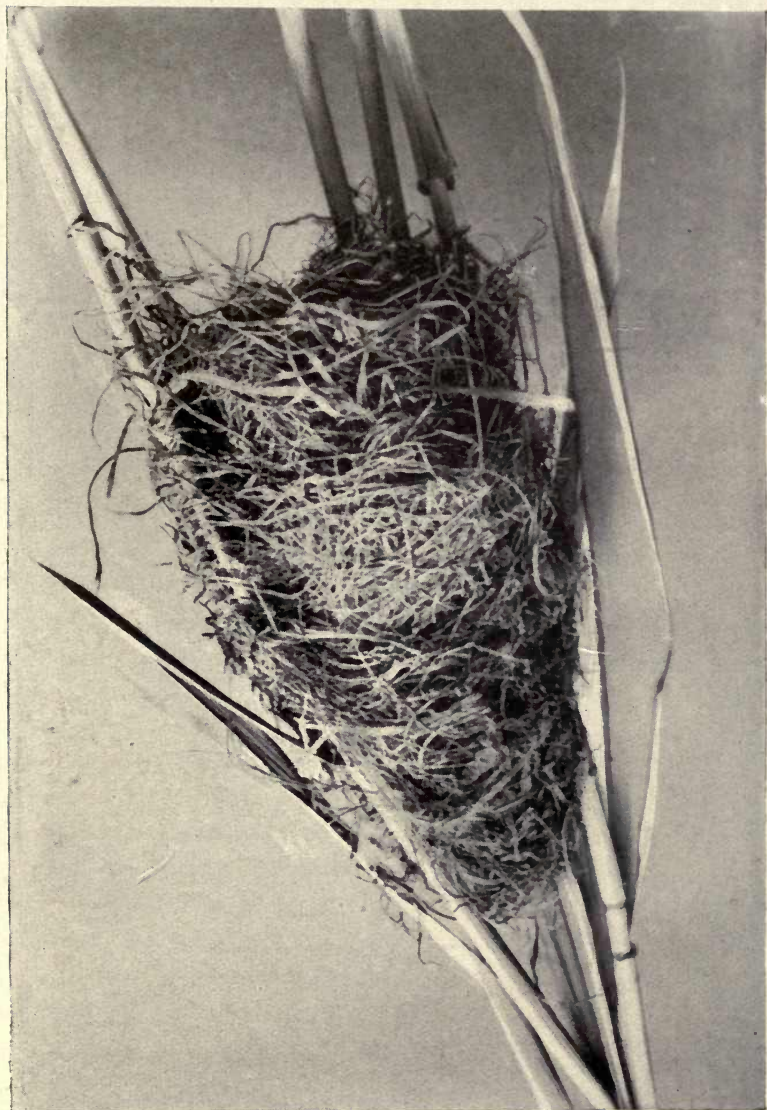
The graceful Swallow and House Martin, whose annual arrival brings to us the promise of returning spring, are both expert masons. Though both may be spoken of in a wide family sense as "Swallows," just as Rooks, Jackdaws, and Ravens may be termed "Crows," there is a plain enough distinction between them and their nests. The Swallow is larger, has longer wings, a longer and more deeply forked tail, and a more sweeping flight, while its upper plumage, but for some slight and inconspicuous markings at the edge of the tail feathers, is dark from head to tail. The House Martin, on the other hand, has the lower half of its back pure white. Again, in choice of nesting site and shape of nest the two birds differ—the Swallow attaching its

How Animals Work.

nest generally to some beam or rafter in a cowshed or other farm outbuilding, while the Martin builds beneath the eaves or window ledges of our houses. The nest of the Swallow is really a wonderful piece of work, consisting of a semicircular saucer or bowl composed of mud pellets, kneaded together with short fragments of straw with wonderful skill, lined with straws and some horsehair and fine grass, and with a final inner lining of feathers. The House Martin builds a nearly globular nest, the walls of which are composed of mud pellets, and it is completely closed save for one small hole. It is lined with bits of straw, and has an inner cushion of feathers, on which the pure white eggs are deposited. The labour of constructing these nests is very great, for neither the Swallow nor the House Martin has a particularly large mouth, so that many hundreds of journeys have to be made backwards and forwards in order to carry sufficient mud for the building of the nest, each tiny beakful being mixed with saliva, which causes the mud to set as a hard natural cement.

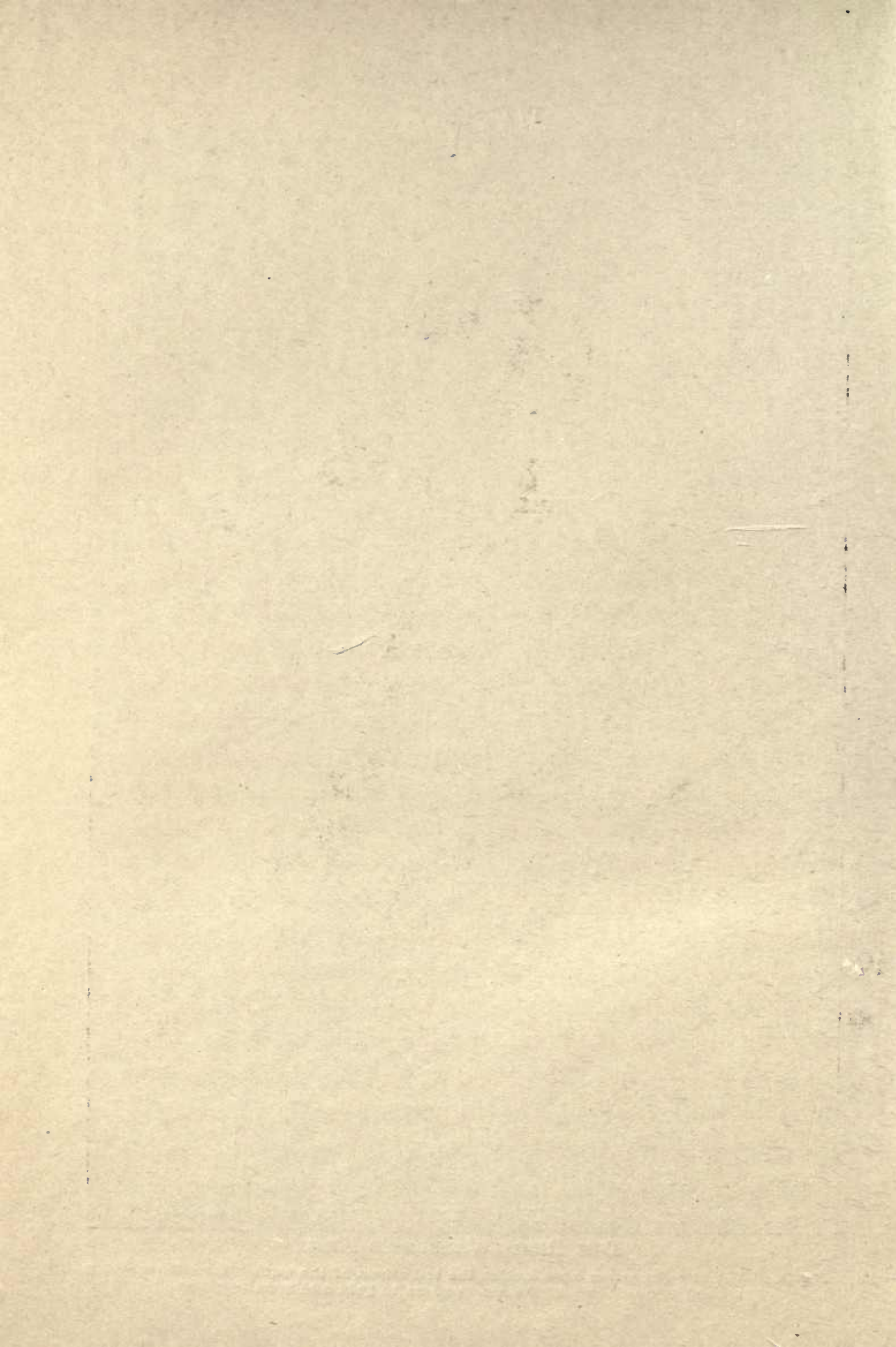
In Gilbert White's day the chimneys of our houses were large, roomy shafts, very different both in structure and appearance from the narrow flue and patent hideous cowl which generally do duty to-day. And it was in those old roomy chimneys that the Swallows loved to build, and of this habit, which the alteration in the general plan and structure of our chimneys has compelled the birds to abandon, Gilbert White gives the following interesting account: "Here and there a bird may affect some odd, peculiar place—as we have known a swallow build down the shaft of an old well, through

PLATE XIV.



THE REED WARBLER'S NEST.

The Reed Warbler slings her nest amidst the tall stems of the swinging reeds, weaving around two or three of the stems so as to gain additional support.



Some Bird Architects.

which chalk had been formerly drawn up for the purpose of manure ; but in general with us this *hirundo* breeds in chimneys, and loves to haunt those stacks where there is a constant fire, no doubt for the sake of warmth. Not that it can subsist in the immediate shaft where there is a fire, but prefers one adjoining to that of the kitchen, and disregards the perpetual smoke of that funnel, as I have often observed with some degree of wonder. Five or six or more feet down the chimney does the little bird begin to form her nest about the middle of May ; which consists, like that of the House Martin, of a crust or shell composed of dirt or mud, mixed with short pieces of straw to render it tough and permanent : with this difference, that whereas the shell of the Martin is nearly hemispheric, that of the Swallow is open at the top and like half a deep dish. This nest is lined with fine grasses, and feathers which are often collected as they float in the air. Wonderful is the address which this adroit bird shows all day long in ascending and descending with security through so narrow a pass. When hovering over the mouth of the funnel, the vibrations of her wings, acting on the confined air, occasion a rumbling like thunder. It is not improbable that the dam submits to this inconvenient situation so low in the shaft in order to secure her broods from rapacious birds, and particularly from owls, which frequently fall down chimneys, perhaps in attempting to get at these nestlings."

CHAPTER XII.

SOME FOREIGN BIRD ARCHITECTS.

AUSTRALIA is an earthly paradise for the naturalist, containing endless wonders of plant and animal life—forms of life, indeed, that we shall meet with nowhere else. Strange insects, strange reptiles and birds, strange mammals, strange and wonderful plants abound, while the seas that bathe its coasts swarm with wonders of the deep. Of its birds, many are beautiful and expert craftsmen, building both dainty and remarkable nests. The delightfully graceful little Fairy Martin takes the place of our House Martin in Australia, crowding its nests together under the eaves of houses, or, in the sparsely populated districts, under the shelter afforded by some overhanging crag on the face of a cliff. "The nest," writes Gould, "which is bottle-shaped with a long neck, is composed of mud or clay, and, like that of our common martin, is only constructed in the morning and evening, unless the day be wet or lowering. While building these nests they appear to work in small companies, six or seven assisting in the formation of each, one of them remaining within and receiving the mud brought by the others in their mouths. In shape the nests are nearly round, but vary

Some Foreign Bird Architects.

in size from four to six inches in diameter, the spouts being eight, nine, or ten inches in length. When built on the sides of rocks, or in the hollows of trees, they are placed without any regular order in clusters of about thirty or forty together, some with the spouts inclining downwards, others at right angles, etc. They are lined with feathers and fine grasses."

The Yellow-throated Sericornis is a very interesting little Australian bird, of a general brownish hue and with a citron-yellow throat, from which it takes its name. It is a shy bird, hiding amongst the denser underwood, rarely indulging in long-sustained flight, but rather flying from thicket to thicket, and spending much time upon the ground in search of insects on which it feeds. The site selected for the nest is a remarkable one, while the ingenuity of its construction aroused the admiration of Gould, the famous ornithologist, who wrote the following interesting account: "All those who have travelled in the Australian forests must have observed that in their more dense and humid parts an atmosphere peculiarly adapted for the rapid and abundant growth of mosses of various kinds is generated, and that these mosses not only grow upon the trunks of decayed trees, but are often accumulated in large masses at the extremities of the drooping branches. These masses often become of sufficient size to admit of the bird constructing a nest in the centre of them, with so much art that it is impossible to distinguish it from any of the pendulous masses in the vicinity. These branches are frequently a yard in length, and in some places hang so near the ground as to strike the head of the explorer during his

How Animals Work.

rambles ; in others, they are placed high up on the trees, but only in those parts of the forest where there is an open space entirely shaded by overhanging foliage. As will be readily conceived, in whatever situations they are met with, they at all times form a remarkable and conspicuous feature in the landscape. Although the nest is constantly disturbed by the wind, and liable to be shaken when the tree is disturbed, so secure does the inmate consider itself from danger or intrusion of any kind that I have frequently captured the female while sitting on her eggs ; a feat that may always be accomplished by carefully placing the hand over the entrance—that is, if it can be detected, to effect which no slight degree of close prying and examination is necessary. The nest is formed of the inner bark of trees, intermingled with green moss, which soon vegetates ; sometimes dried grasses and fibrous roots form part of the materials of which it is composed, and it is warmly lined with feathers.”

The different species of Australian Honey-eaters are all dainty architects, who build hanging or pensile nests. That of the Singing Honey-eater, whose song Gould compares to the song of the missel thrush, is built in New South Wales, of the very finest dry stalks that the bird can find, lined with fibrous roots, matted together with spiders' webs, and fastened by its rim to the slender, pendulous twigs of the beautiful myall tree (*Acacia pendula*). In Western Australia we find this bird using different material, while preserving the general structural features of the nest. It collects grasses, which, although green when first woven into the nest, soon become white and dry. With the grasses

Some Foreign Bird Architects.

is woven the hair of the kangaroo and one of the so-called opossums, so as to make the walls fairly weather-proof, while the interior receives a soft lining of finer grasses and cotton down obtained from various plants. The Painted Honey-eater also hangs its nest amidst the pendulous twigs and leaves of the myall tree; but it is a far less substantial structure, composed of finest fibrous roots daintily but loosely interwoven, so that it is really a very frail nest, and a most difficult one to procure without damage. The Lanceolate Honey-eater builds a perfectly charming and most fairy-like cradle for its precious eggs. The little bird frequents the Liverpool Plains of Australia, where, on myall trees whose branches overhang some quiet stream, it builds its dainty nest. For building materials the bird collects grass, wool, and pure white cotton from various plants, and with these it constructs a deep, somewhat pouch-shaped nest, which is slung hammock fashion from the slender twigs of the tree. In quiet, sheltered spots, amidst the masses of mangroves which fringe the bogs and creeks, the White-throated Honey-eater makes its home; and here, attached to some low, slender branch that stretches out over the water, its curious hanging nest is to be found. In shape and size the nest rather resembles a good-sized breakfast cup, and the bird uses in its construction the delicate, paper-like bark of the *Melaleuchæ*, and various rootlets and vegetable fibres, the interior being lined with fine, soft grasses.

Two more interesting examples of Australian birds which build hanging nests are the Rock Warbler, or Cataract Bird, and the dainty wee *Dicæum* Swallow.

How Animals Work.

The Rock Warbler, or Cataract Bird, is a small brown bird with a dull red tint upon the breast, and is scarcely as big as our common sparrow. As one of its popular names denotes, it is a bird which invariably frequents such situations as mountain streams when they rush through rocky channels, and it is in such surroundings, wherever some rock ledge overhangs the stream and affords suitable shelter, that the bird builds its nest. This is really a very remarkable structure, calling for considerable patience and skill in its weaving. The material used by the bird is the long moss which grows plentifully at hand, and with this the Rock Warbler builds a nest which in shape somewhat resembles an old-fashioned claret jug without a handle, but having a long, slender neck terminating abruptly in a more or less globular body. Though of rather rough exterior, the nest is soft and snug within, and the entrance is near the centre of the bulbous expansion. The birds appear to be of a social disposition, for they will hang their nests by dozens in quite close proximity to each other on the face of some particularly favoured site. The Dicæum Swallow is a wee, bright-coloured bird scarcely as large as the wren, and frequents the tops of the tallest trees. Its upper plumage is a beautiful glossy blue-black, while the throat and breast are a vivid scarlet, and the stomach pure white. High up at the top of a tree—the myall or weeping acacia being a favourite—the graceful little bird hangs its beautiful nest, which when first built is of purest white hue. The tiny feathered architect uses nothing but the white, cotton-like down which it collects from various seeding plants, and with this material fashions a more or less pouch-

Some Foreign Bird Architects.

purse-shaped nest, suspended at its apex from some slender topmost branch.

Two most remarkable nest-builders are the Australian Mallee Bird (*Leipoa ocellata*) and the Mound Bird (*Megapodius tumulus*), both of which build upon the ground mounds of considerable dimensions which are used as nests. The Mallee Bird, according to Gilbert, selects as its nesting site densely wooded, gravelly hills on which the forest growth of tall eucalyptus trees overshadows the thick undergrowth. Here the bird makes its mound by scratching up the gravel, and mixing with that intended for the interior of the mound a quantity of plant material, so as to form a regular hotbed as it were; for this central mass in which the eggs are deposited soon begins to ferment and decay, so that the temperature rises as high as 89° Fahrenheit, and sufficient warmth is generated to incubate the eggs. Of the way in which the Mallee Bird constructs this curious nest, or natural incubator, Sir George Grey has given the following account:—"The mound appears to be constructed as follows. A nearly circular hole, about eighteen inches in diameter, is scratched in the ground to a depth of seven or eight inches, and filled with dead leaves, dead grass, and similar materials, and a large mass of the same substances is placed all round it upon the ground. Over this first layer a large mound of sand, mixed with dry grass, etc., is thrown, and finally the whole assumes the form of a dome. When an egg is deposited, the top is laid open and a hole scraped in its centre to within two or three inches of the bottom layer of dead leaves. The egg is placed in the sand just at the edge of the hole,

How Animals Work.

in a vertical position, with the smaller end downwards. The sand is then thrown in again, and the mound left in its original form. The egg which has been thus deposited is therefore completely surrounded and enveloped in soft sand, having from four to six inches of sand between the lower end of the egg and the layer of dead leaves. When a second egg is laid, it is deposited in precisely the same plane as the first, but at the opposite side of the hole before alluded to. A third egg is placed in the same plane as the others, but, as it were, at the third corner of the square; the fourth in the fourth corner—the figure being in

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this form : o o. The next four eggs in succession

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are placed in the interstices, but always in the same plane, so that at last there is a circle of eight eggs, all standing upright in the sand, with several inches of sand intervening between each. The male bird assists the female in opening and covering up the mound, and provided the birds are not themselves disturbed, the female continues to lay in the same mound, even after it has been several times robbed. The natives say that the hen bird lays an egg every day."

The Mound Bird, or Megapode (*Megapodius tumulus*), does not make a regular hotbed of vegetation like the Mallee Bird; but its mounds frequently attain to very considerable proportions, being added to season after season, until they assume such large proportions that it is no uncommon thing to find trees growing upon them as if they were natural hillocks of earth. The birds build these mounds in dense thickets close

Some Foreign Bird Architects.

to the seashore, or on the shore itself, those built in the latter situation being often very irregular in shape, and generally formed of sand and shells. Some of these shore mounds have been found to measure as much as a hundred and fifty feet in circumference ; while the mounds built in the thickets are more regular in shape, and generally composed of a light black vegetable soil. The parent birds dig down into these mounds from the top, excavating holes in which the eggs are placed, their incubation being accomplished by the heat of the sun's rays pouring down upon the mound and raising the temperature within.

Gould has left the following particulars concerning the mounds made by these remarkable birds ; and his remarks and observations are of particular value, as these birds are almost certain to grow rarer as the country becomes opened up and more populated. " I revisited Knocker's Bay," writes Gould, " and having with some difficulty penetrated into a dense thicket of cane-like creeping plants, I suddenly found myself beside a mound of gigantic proportions. It was fifteen feet in height and sixty in circumference at the base, the upper part being about a third less, and was entirely composed of the richest description of light vegetable mould ; on the top were very recent marks of birds' feet. The native and myself immediately set to work, and after an hour's extreme labour, rendered the more fatiguing from the excessive heat and the tormenting attacks of myriads of mosquitoes and sand-flies, I succeeded in obtaining an egg from a depth of about five feet. It was in a perpendicular position, with the earth surrounding and very lightly touching

How Animals Work.

it on all sides, and without any other material to impart warmth—which, in fact, did not appear necessary, the mound being quite warm to the hands. The holes in this mound commenced at the outer edge of the summit, and ran down obliquely towards the centre; their direction was therefore uniform. Like the majority of the mounds I have seen, this was so enveloped in thickly foliated trees as to preclude the possibility of the sun's rays reaching any part. The mounds differ very much in their composition, form, and situation; most of those that are placed near the water's edge were formed of sand and shells, without a vestige of any other material, but in some of them I met with a portion of soil and decaying wood. When constructed of this loose material they are very irregular in outline, and often resemble a bank thrown up by a constant surf. One remarkable specimen of this description, situated on the southern bank of Knocker's Bay, has the appearance of a bank from twenty-five to thirty feet in length, with an average height of five feet. Another, even more singular, is situated at the head of the harbour, and is composed entirely of pebbly ironstone, resembling a confused heap of sifted gravel; into this I dug to the depth of two or three feet without finding any change of character. It may have been conical originally, but is now without any regularity, and is very extensive, covering a space of at least a hundred and fifty feet in circumference. These remarkable specimens would, however, seem to be exceptions, as by far the greater number are entirely formed by light black vegetable soil, are of conical form, and are situated in the densest thickets. Occa-

Some Foreign Bird Architects.

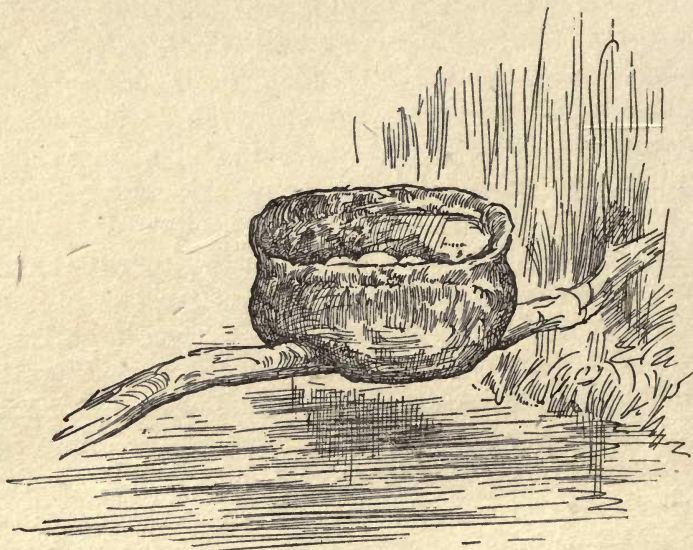
sionally the mounds are met with in barren, rocky, and sandy situations, where not a particle of soil similar to that of which they are composed occurs for miles round ; how the soil is produced in such situations appears unaccountable. It has been said that the parent birds bring it from a great distance ; but as, as we have seen, they readily adapt themselves to the difference of situation, this is scarcely probable. I conceive that they collect the dead leaves and other vegetable matter that may be at hand, and which, decomposing, forms this particular description of soil. These mounds are doubtless the work of many years, and of many birds in succession ; some of them are evidently very ancient, trees being often seen growing from their sides. In one instance I found a tree growing from the middle of a mound which was a foot in diameter.” *

The Australian Magpie-lark, or Pied Grallina, is a wonderfully graceful, elegant bird, and singularly tame and confiding in disposition, boldly visiting the verandas of the houses, along which it will run in a manner very similar to that of our British Pied Wag-tail. Needless to say, it is a great favourite with all bird-loving residents. The nesting season is in October and November, and then the Pied Grallina shows itself to be an elegant worker in clay, with which material it builds a nest. Most birds seek at least to partially hide their nests from view, or by using suitable materials, such as moss and lichens, strive to make them resemble their surroundings in colour and appearance. Not so the Pied Grallina, which seems almost to go out of its way to make its nest as conspicuous an object as pos-

* Gould's *Handbook to the Birds of Australia*.

How Animals Work.

sible. One of its favourite nesting sites is the most exposed and bare horizontal branch it can find, either in the open forest or overhanging a stream. In such a noticeable situation the bird will set to work, and with soft clay will construct a remarkably solid nest, from five to six inches in breadth and three inches in depth. The clay soon becomes hard and solid upon



Nest of the Australian Magpie-lark.

exposure to the atmosphere and the hot rays of the sun, so that the finished nest assumes the appearance of a massive, clay-coloured earthenware vessel, which varies in colour with that of the material of which it is formed. Sometimes the locality of the nest site will yield no mud or clay, and then the nest is constructed of black and brown mould; and the *Grallina*, as if fully aware that this substance will not hold to-

Some Foreign Bird Architects.

gether for lack of the adhesive quality of clay, proceeds to mix with the earth a great quantity of dried grass stalks and similar material, and thus forms a firm, hard exterior to the nest, while the inside is slightly lined with grass and a few feathers.

Another singularly confiding little bird, except in the breeding season, when it exhibits extreme anxiety at the approach of an intruder to the vicinity of its nest, is the White-shafted Fantail, which is very common about Parramatta. Except in the breeding season, the little bird will allow you to approach it quite closely, and will not infrequently dash in at an open door in pursuit of gnats and other insects upon which it feeds. About October it begins to think of nesting, and looks about for a suitable site, always selecting a spot low down, within a few feet of the ground; though the locality varies a good deal, for it will build in the midst of dense bushes, in the open forest, or place its nest on a branch overhanging a mountain rivulet. The nest is a most elegant piece of work, closely resembling a wineglass in shape, and is woven together with exquisite skill. It is generally composed of the inner bark of a species of eucalyptus, neatly lined with the down of the tree-fern intermingled with flowering stalks of moss, and outwardly fastened together with spiders' webs, which not only serve to envelop the nest, but are also employed to strengthen its attachment to the branch on which it is constructed. Altogether it is as dainty an example of bird architecture as one could well imagine.

One of the most remarkable nest-builders in Brazil is the Oven Bird, which is an expert mason, construct-

How Animals Work.

ing a wonderfully solid and striking-looking nest. Of its general appearance and the nesting site Burmeister gives the following interesting account :—" When we have passed the lofty mountain chains which divide the vast coast forests of Brazil from the plains of the campos, and descend the hills of the Rio das Velhas valley, there on all sides one notices, in the great trees which stand solitary in the neighbourhood of dwellings, large melon-shaped masses of earth on the stout, spreading branches. Their appearance is striking. You might take them to be the nests of termites ; but then they have an opening on one side, and they are all of one size and shaped alike, while the constructions of termites are irregular in form and are never placed freely on a branch, but always at a point where it is forked. We soon find out, however, what is the true nature of these heaps of earth ; we recognize the large oval aperture at the side, and presently we may see going in and out a little bird with warm brown plumage : it is, in fact, a bird's nest—that of the Oven Bird, known to every native by the name of ' Johnny Clay,' ' João de barro.' "

Like the Australian Pied Grallina, the Oven Bird does not appear to pay particular heed to the concealment of its nest ; and, indeed, the safe hiding of so conspicuous an object would be no easy matter. Various sites, however, are selected ; for in addition to the exposed position on the boughs of solitary trees, as described by Burmeister, the bird will build in fairly dense bushes, and sometimes on beams in sheds and outhouses. The walls of the dome-shaped nest are about an inch in thickness, so that it is a most remark-

Some Foreign Bird Architects.

ably solid structure, the materials of which it is built consisting of mud and clay, further stiffened by the admixture of grass, vegetable fibres, and the stems of various plants. But to fully appreciate what a wonderful piece of work this large nest really is, one must carefully divide a specimen in half, so as to obtain a clear view of the interior. There one discovers that crossing the nest from side to side is a kind of partition wall, composed of the same materials as the outer wall and reaching nearly to the top of the dome of the nest; so that, practically, the nest is divided into two chambers, the inner chamber being lined with a soft bed of feathers, on which the eggs are deposited. Considering the complex character of the nest, it is constructed in a remarkably short space of time, the birds labouring with untiring zeal at their task, so that a nest is often completed in the space of some five or six days. Both cock and hen birds work with equal enthusiasm at the construction of the nest, flying backwards and forwards carrying beakfuls of mud and clay. This is first of all spread out with the aid of beak and claw so as to make a regular and firm foundation, and then the birds begin to build upon its edges the rim of the nest, which at first slopes slightly outwards. Gradually, layer upon layer, the nest is in this way built up, until the dome is completed. The entrance to the nest is at one side, and is a fairly high, narrow opening with a curved margin, about two inches wide and nearly four inches high, large enough to permit the ready ingress and egress of the birds. The natives appear to have many curious superstitions concerning the Oven Bird, for which they have considerable affec-

How Animals Work.

tion, one popular belief being that the bird is of a highly pious nature and refrains from the labour of nest-building on Sundays. Careful observation of one or two pairs engaged in their architectural labours, however, will suffice to show that this is not the case, the birds labouring as steadily and cheerfully upon a Sunday as on any other day in the week.

Another expert worker in clay is the Syrian Nuthatch, which selects as its nesting site the face of some steep overhanging rock the recesses of which afford shelter and at the same time are difficult of access. In one of these recesses the bird builds its funnel-shaped nest, using for the building materials mud mixed with fragments of dry grass. The base of the nest frequently attains to twenty-four or twenty-six inches in circumference, while the walls are quite substantial, and vary from half an inch to fully an inch and a half in thickness. The neck of the funnel, by means of which the bird enters and leaves the nest, varies a good deal in length, and though generally measuring about four inches, sometimes attains to a foot. Within, this remarkable structure is lined with goat's wool, thistle-down, and any other soft material that can be collected in the vicinity of the nesting site. The bird appears to take considerable care in so plastering the outside of its nest as to make it resemble as closely as possible the appearance of the face of the rock against which it is built. It is also stated to evince great pleasure in its mason work, not infrequently building several nests besides the one specially intended for the rearing of its offspring.

Our British Nuthatch, like the Titmice, generally

Some Foreign Bird Architects.

nests in a hole in a tree, but on occasion will, it would seem, depart from this general rule and construct a nest entirely of mud. Such a nest, composed of mud, and built into the side of a haystack, was presented some years ago to the British Museum by Mr. Bond, together with the following interesting particulars:—
“I have received this summer from the neighbourhood of East Grinstead a nest built by a pair of Nuthatches, which is so remarkable in its construction, and in the site selected for it, that I think a notice is worth recording. It is well known that the Nuthatch almost invariably makes use of a hole either in a tree or wall in which to deposit its eggs, and is not, in the strict sense of the word, a nest-builder. In this instance a haystack was selected, and the birds, by pulling out a quantity of hay and plastering up the hollow with mud brought from a considerable distance, formed a nest of similar construction to that of a swallow, but very much larger, with an entrance hole near the top, and the ends of the hay stems neatly embedded in the mud.” The nest had been built at a height of five or six feet from the ground, and the birds first attracted the attention of some farm labourers who observed them pulling the hay from the stack. This the Nuthatches continued to do until they had formed a large opening, and not until this gap had been formed did they commence building with mud, which had to be carried from a point some one hundred and fifty yards distant from their strange nesting site. The labour occupied a considerable time, the farm hands stating that they had watched the birds at work upon the construction of their nest for quite six weeks. This

How Animals Work.

truly remarkable nest, when cut out of the haystack, weighed nearly eleven pounds, and measured thirteen inches in length, by eight inches in its greatest width, and four inches in thickness ; while it was lined with fragments of the scaly inner bark of the fir tree.

That extraordinary-looking bird the Hornbill, although not strictly speaking a nest-builder, is yet something of a mason. Its nesting site is a convenient hole in a tree, and within this hole the female bird actually permits herself to be walled up by the male bird, who plasters up the entrance to the hole with mud and clay, leaving only a small opening through which he can pass food to his voluntarily imprisoned spouse. This curious habit is considered by some authorities as probably a means of protecting the hen bird from the attacks of monkeys and monitor lizards while she is sitting on the eggs and brooding her young ; and as at the same time she appears to pass through the process of moulting, when for a short time scarcely a flight feather is left on her wings, she is safe from the danger of toppling out of the nest and being unable, owing to the state of her wings, to return. But whatever the reason, she is walled up by her truly devoted husband when the time comes for her to sit upon the eggs, and she does not regain her liberty until the young are nearly, if not quite, fully fledged. During the whole of this fairly lengthy incarceration the devoted male bird mounts guard outside, and is busily engaged in collecting and bringing back food supplies, first for his wife, and later for both mother bird and hungry offspring, so that by the end of the nesting season he presents a very careworn appearance, and is quite

Some Foreign Bird Architects.

exhausted by his toils—"a very shadow of his former self."

Dr. Livingstone has given the following very interesting account of his observations of one of the Hornbills during his missionary travels in South Africa. "The first time I saw this bird," he writes, "was at Kolobery, where I had gone to the forest for some timber. Standing by a tree, a native looked behind me and exclaimed, 'There is the nest of a Korwe.' I saw a slit only, about half an inch wide and three or four inches long, in a slight hollow of a tree. Thinking the word 'korwe' denoted some small animal, I waited with interest to see what he would extract. He broke the clay which surrounded the slit, put his arm into the hole, and brought out a Tockus, or Red-beaked Hornbill, which he killed. He informed me that when the female enters her nest she submits to a real confinement. The male plasters up the entrance, leaving only a narrow slit by which to feed his mate, and which exactly suits the form of his beak. The female makes a nest of her own feathers, lays her eggs, hatches them, and remains with the young until they are fully fledged. During all this time, which is stated to be two or three months, the male continues to feed her and the young family. The prisoner generally becomes quite fat, and is esteemed a very dainty morsel by the natives; while the poor slave of a husband gets so lean that on the sudden lowering of the temperature, which sometimes happens after a fall of rain, he is benumbed, falls down, and dies." Wallace describes the capture of a young Hornbill and the outward appearance of the nest, as he saw it in Sumatra, as follows:—"I returned

How Animals Work.

to Palembang by water, and while staying a day at a village while a boat was being made watertight, I had the good fortune to obtain a male, female, and young bird of one of the large Hornbills. I had sent my hunters to shoot, and while I was at breakfast they returned, bringing me a fine large male of the *Buceros bicornis*, which one of them assured me he had shot while feeding the female, which was shut up in a hole in a tree. I had often read of this curious habit, and immediately returned to the place, accompanied by several of the natives. After crossing a stream and a bog, we found a large tree leaning over some water, and on its lower side, at a height of about twenty feet, appeared a small hole, and what looked like a quantity of mud, which I was assured had been used in stopping up the large hole. After a while we heard the harsh cry of a bird inside, and could see the white extremity of its beak put out. I offered a rupee to any one who would go up and get out the bird, with the egg or young one; but they all declared it was too difficult, and they were afraid to try. I therefore very reluctantly came away. In about an hour afterwards, much to my surprise, a tremendous loud, hoarse screaming was heard, and the bird was brought me, together with a young one which had been found in the hole. This was a most curious object, as large as a pigeon, but without a particle of plumage on any part of it. It was exceedingly plump and soft, and with a semi-transparent skin, so that it looked more like a bag of jelly, with head and feet stuck on, than like a real bird." The devotion of the male Hornbill to the care of his imprisoned family is very touching,

Some Foreign Bird Architects.

and it is curious to note that in captivity the bird will throw up his food and not only offer it to his mate, though she is not walled up in a tree, but will offer food in the same way to his keeper or any other human friend for whom he may form an attachment.

The Fantail Warbler, common over the whole of Southern Europe, and in Africa, India, and China, is a highly skilled little architect, building a singularly beautiful and dainty nest. Its favourite nesting site is a patch of dense fine-stemmed grass, from eighteen inches to two feet in height, growing in a moist situation. Around two or three of the upright grass stalks the little bird weaves a framework of cotton or other fibrous material at a height of between ten inches and fourteen inches from the ground, the material being sewn into the grass and passed from one stalk to another, the blades and stems being closely tacked and caught together with cobwebs and very fine, silky vegetable fibre, so that a narrow tube is formed. This accomplished, the little bird proceeds to bend down several blades belonging to the stalks which have been connected together, and to interlace them so that they form a bottom to the tube. The whole of the interior is then lined with closely felted cotton or other downy substance. The completed nest forms a deep and narrow purse of about three inches in depth, and an inch in diameter at the top, and one-fifth of an inch at the broadest part below. The stems of grass are generally tacked together a good deal higher up on one side than on the other, and it is through or between the untacked stems opposite to this that the tiny entrance to the nest is made. The stems and blades

How Animals Work.

of grass meeting above the nest form a perfect shelter from the weather, and also screen it completely from view. In this dainty little nest we have a combination of weaving and actual stitching which is particularly interesting, and shows a high degree of skill on the part of the enthusiastic little bird, which works away with such untiring and persistent energy that, from start to finish, the building of the nest is often completed within five days.

And now I come to a well-known and truly remarkable bird craftsman, whose highly skilled work has long been a source of wonder and admiration: this is the Tailor Bird, familiar throughout the whole of the Indian peninsula, Burma, and China. In these countries it appears to be most common in well-wooded districts, and is a familiar bird about the gardens, orchards, and hedgerows, where it eagerly hops about among the branches of the trees and shrubs, hunting for the various small insects upon which it feeds. A good deal of individuality seems to be displayed on the part of the bird in the construction of its nest; for while some are most highly finished, the leaves being sewn together with the greatest care and neatness, in others it is of far inferior character. The breeding season in India lasts from May to August, and the wonderful little nest consists of a deep, soft cup enclosed in leaves, which the Tailor Bird sews together so as to form a perfect protecting sheath (Plate XV.). "The nests vary very much in appearance," writes Mr. Hume, "according to the number and description of leaves which the bird employs, and the manner in which it employs them; but the nest itself is usually

Some Foreign Bird Architects.

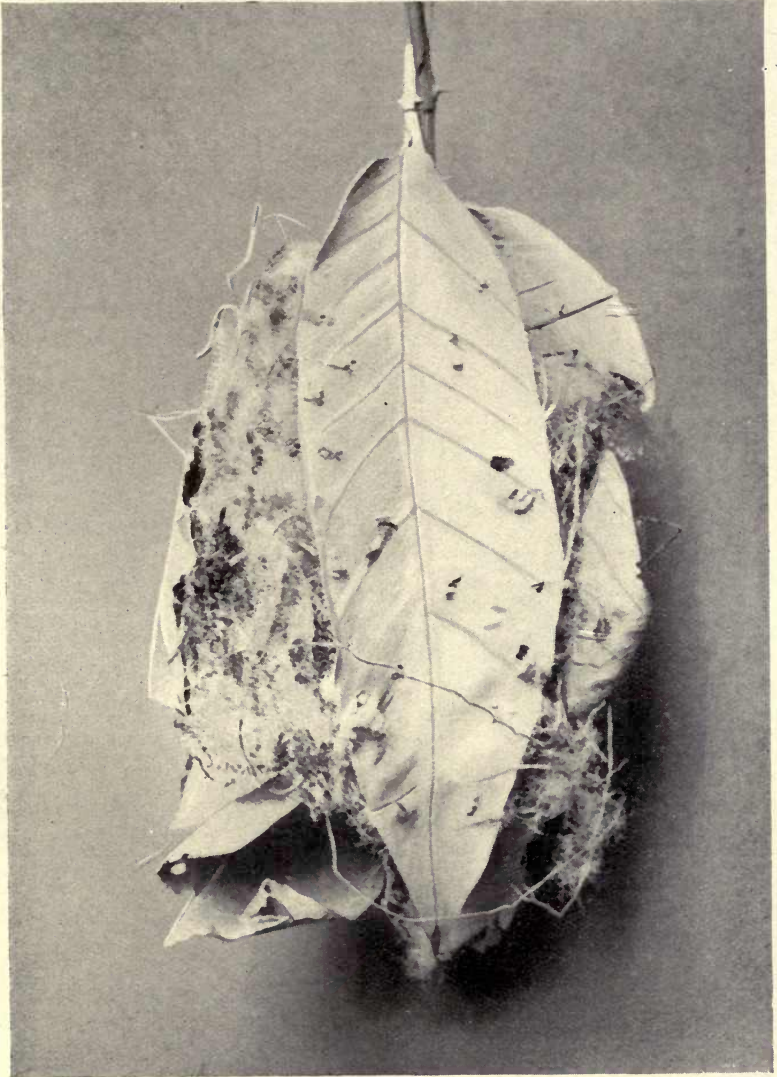
chiefly composed of fine cotton wool, with a few horse-hairs, and, at times, a few very fine grass stems as a lining, apparently to keep the wool in its place and enable the cavity to retain permanently its shape. I have found the nests with three leaves fastened, at equal distances from each other, into the sides of the nest, and not joined to each other at all. I have found them between two leaves—the one forming a high back, and turned up at the end to support the bottom of the nest; the other hiding the nest in front, and hanging down well below it, the tip only of the first leaf being sewn to the middle of the second. I have found them with four leaves sewn together to form a canopy and sides, from which the bottom of the nest depended bare; and I have found them between two long leaves whose sides, from the very tips to near the peduncles, were closely and neatly sewn together. For sewing they generally use cobwebs; but silk from cocoons, thread, wool, and vegetable fibres are all useful.” Of a nest which the same writer obtained at Bareilly he states that “three of the long, ovato-lanceolate leaves of the mango, whose peduncles sprang from the same point, had been neatly drawn together with gossamer threads run through the sides of the leaves and knotted outside, so as to form a cavity like the end of a netted purse, with a wide slit on the side nearest the trunk, beginning near the bottom, and widening upwards. Inside this the real nest, nearly three inches deep, and about two inches in diameter, was neatly constructed of wool and fine vegetable fibres, the bottom being thinly lined with horsehair. In this lay three tiny delicate bluish-white eggs, with a few pale reddish-brown

How Animals Work.

blotches at the large ends, and just a very few spots and specks of the same colour elsewhere." By means of its rather slender, sharp-pointed beak the Tailor Bird pierces the necessary holes along the edges of the leaves, then passes the sewing material through them and draws them together, generally so as to form a kind of hollow, downward-pointing cone.

Several of the Humming Birds make more or less purse-like nests, which they attach to the extremity or to the middle of some suitable, broadly lanceolate leaf. The beautiful little Hermit Humming Bird, for instance, builds a singular pouch nest, which has a sort of long tail depending from its base, and this nest is attached to the extremity of a leaf. For building materials the silky fibres of plants, the cotton down from various seed vessels, and the woolly sort of substance procured from a species of fungus are used—all being woven together with spiders' webs, by means of which the nest is also attached to the leaf. The Gray-throated Hermit Humming Bird attaches its nest, composed of moss fibres bound together with gossamer webs, near the centre of the leaf. The Pigmy Hermit also attaches its nest to a leaf in much the same manner. This wee bird makes great use of downy seeds as building material, the exterior of the nest being covered with them, while inside it is lined with the same material and strengthened with the most delicate fibres of flowering plants. The dainty little nest is cup-shaped, with a long tail-like appendage which gives it rather the appearance of a delicate funnel. A particularly dainty nest, usually suspended from the tip of some conveniently placed palm leaf,

PLATE XV.



THE WONDERFUL NEST OF THE TAILOR BIRD.

The leaves are stitched to the body of the nest with fine plant fibres, cotton, and cobwebs.

Some Foreign Bird Architects.

is that of the Sawbill Humming Bird. This bird has gained its popular name from the curious formation of its long, slender beak, which for a short distance from the tip is notched in a sawlike fashion on the edges of both the upper and the lower mandible. Using fine vegetable fibres, the Sawbill Humming Bird weaves them together so as to form a dainty open-network purse nest, the outer walls of which are so loosely woven that the eggs and lining can be seen through the interstices. Leaves, mosses, and lichens are woven into the body of the nest, and a compact layer of this material forms a soft bed for the eggs, but the edge of the nest is always a loosely woven lattice-work as already described. Practically all the Humming Birds build interesting and daintily constructed nests, and it seems a cruel and disgraceful thing that many of these exquisite wee birds have been so ruthlessly slaughtered, in such wholesale numbers, for the sake of their glorious plumage that they are fast approaching total extinction.



Nest of the Pigmy Hermit Humming Bird.

How Animals Work.

For the most marvellous examples of nest-weaving we must look to the true Weaver Birds and the Hang-nests, or *Icteridæ*, to give them their scientific name. The Hang-nests are a strictly American family of birds, some species showing marked affinities to the Starlings, while their long, purse-like nests suggest their affinity to the Weaver Birds. One of the most familiar of these American Hang-nests is the Baltimore Oriole, a sweet-voiced, handsome bird common throughout New England. It is interesting to find that this beautiful bird varies both the materials used in the construction of its nest, and the nesting site, according to the part of America it is inhabiting. Thus, in the Northern States, the nest is placed in as sheltered and sunny a spot as can be found, and is snugly lined with the finest and warmest materials closely woven together; while down in the South the nest is placed in a well-shaded spot well screened from the fierce rays of the noontide sun, and is frequently built entirely of lichens, quite loosely woven together, so that plenty of air can circulate through its walls, the soft, warm lining of the Northern nest being altogether absent.

The nest is a very beautiful piece of work, measuring about six or seven inches in length, pouch-shaped, and rather deeper than its total width, skilfully woven of moss, lichens, and any plant fibres that can be obtained; flax, wool, tow, and hair of any description also being used. Indeed, it is stated that the birds will carry off any lengths of cotton thread or silk that they can find about the gardens or verandas of the houses, and will do their best to try to unfasten the threads by which the farmer has fastened his grafts on to the

Some Foreign Bird Architects.

trees in the orchards. The finished nest is attached by its rim at several points to the branch selected by the bird.

The Orchard Oriole, or Bobolink, a closely allied species, is an equally skilful weaver. It is fond of building in the weeping willow tree, whose drooping leaves afford a most effectual concealment, while the delicate twigs are often fastened together so as to support the entire circumference of the entrance to the nest. The Cassique, or Crested Oriole, is quite as sociable in its habits as the Baltimore Oriole, frequenting gardens and orchards, so that its habits can easily be observed. Its nest is pocket-shaped, but is considerably longer than that of the Baltimore Oriole, and of much looser texture, and generally built of rather coarser material, vegetable fibres and strips of bark being used in its construction. In collecting the strips of bark the Cassique displays considerable ingenuity, pulling up a little tag of the outer bark with the aid of its beak, and then seizing it and flying along the branch in such a way as to peel off a long, thin strip. With this material and other plant fibres the bird weaves a nest some five to six inches in diameter, and often three to four feet in length.

The true Weaver Birds are distributed over Africa, India, and the Malay Peninsula, and their nests are certainly among the most interesting productions of bird architecture. How wonderfully perfect is their art can be seen by reference to the photograph (Plate XVI.), which shows a particularly perfect example. The common Baya Weaver Bird (*Ploceus baya*) is found throughout that wonderful land, from Cape Comorin

How Animals Work.

and Ceylon to the foot of the Himalayas, extending into Assam, Burma, and Malaysia. "Its long, retort-shaped nest," writes Dr. Jerdon, "is familiar to all; and it is indeed a marvel of skill, as elegant in its form as substantial in its structure, and weather-proof against the downpour of a Malabar or Burmese monsoon. It is very often suspended from the fronds of some lofty palm tree, either the palmyra, cocoa-nut, or date; but by no means so universally as Mr. Blyth would imply, for a babool or other tree will often be selected in preference to a palm tree growing close by, as I have seen within a few miles from Calcutta on the banks of the canal. In India I have never seen the Baya suspend its nest except on trees; but in some parts of Burma, and more particularly in Rangoon, the Bayas usually select the thatch of a bungalow to suspend their nests from, regardless of the inhabitants within. In the cantonment of Rangoon very many bungalows may be seen, with twenty, thirty, or more of these long nests hanging from the end of the thatched roof, and in one house in which I was an inmate a small colony commenced their labours towards the end of April; and in August, when I revisited that station, there were above one hundred nests attached all round the house! In India, in some localities, they appear to evince a partiality to build in the neighbourhood of villages or dwellings; in other places they nidificate in most retired spots in the jungle, or in a solitary tree in the midst of some large patch of rice cultivation." From the above description we learn, therefore, that the Baya Weaver Bird by no means always selects the same nesting site for its habitation.

Some Foreign Bird Architects.

Of the manner in which the wonderful nest is woven Dr. Jerdon gives the following minute and deeply interesting account :—"The nest is frequently made of grass of different kinds plucked when green, sometimes of strips of plantain leaf, and not infrequently of strips from the leaves of the date palm or coconut ; and I have observed that nests made of this last material are smaller and less bulky than those made with grass, as if the little architects were quite aware that with such strong fibre less amount of material was necessary. The nest varies much in the length both of the upper part, or support, and the lower tube, or entrance, and the support is generally solid from the point whence it is hung for two or three inches, but varies much both in length and strength. When the structure has advanced to the spot where the birds have determined the egg compartment to be, a strong transverse loop is formed, not in the exact centre, but a little at one side. If this is taken from the tree and reversed, the nest has the appearance of a basket with its handle, but less so in this than in other species, which have seldom any length of support above. Various authors have described this loop or bar as peculiar to the male nest or sitting nest, whereas it exists primarily in all, and is simply the point of separation between the real nest and the tubular entrance, and, being used as a perch both by the old birds and the young (when grown sufficiently), requires to be very strong. Up to this time both sexes have worked together indiscriminately, but when this loop is completed the female takes up her seat upon it, leaving the cock bird to fetch more fibre and work from the

How Animals Work.

outside of the nest, whilst she works on the inside, drawing in fibres pushed in by the male, reinserting them in their proper place, and smoothing all carefully. Considerable time is spent in completing this part of the nest, the egg chamber formed on one side of the loop and the tubular entrance at the other, after which there appears to be an interval of rest. It is at this stage of the work—from the formation of the loop to the time that the egg compartment is ready—that the lumps of clay are stuck on about which there have been so many and conflicting theories. The original notion—derived entirely, I believe, from the natives—was that the clay was used to stick fire-flies on, to light up the apartment at night. Layard suggests that the bird uses it to sharpen its bill on; Burgess, that it serves to strengthen the nest. I, of course, quite disbelieve the fire-fly story, and doubt the other two suggestions. From an observation of several nests, the times at which the clay was placed in the nests, and the position occupied, I am inclined to think that it is used to balance the nest correctly, and to prevent its being blown about by the wind. In one nest lately examined there was about three ounces of clay in six different patches. It is generally believed that the unfinished nests are built by the male for his own special behoof, and that the pieces of clay are more commonly found in them than in the complete nest. I did not find this the case at Rangoon, where my opportunities for observing the bird were good, and believe rather that the unfinished nests are either rejected, if built early in the breeding season, or if late, that they are simply the efforts of that constructive faculty which appears, at this season,

Some Foreign Bird Architects.

to have such a powerful effect on this little bird, and which causes some of them to go on building the long tubular entrance long after the hen is seated on her eggs." *

The different species of Weaver Birds all build characteristic nests. Thus the Mahali Weaver Bird of South Africa constructs a wonderfully stout nest of considerable size, shaped rather like a Florence oil flask with a shortened wide neck. In weaving this nest the bird contrives that the ends of all the stout grass stalks project outwards and point downwards, so that, although they give a rather rough appearance to the exterior, they serve very effectively as eaves to throw off the rain from the nest. Another species (*Ploceus ocularius*) weaves a nest that looks like a chemist's retort suspended bulb upwards, and uses in its construction a very stiff, narrow, and elastic grass, the stem of which is about the thickness of very fine twine. Although, as it hangs from the tree, this basket-work model of an inverted chemist's retort looks a somewhat unsafe home for young restless fledglings, who might struggle up from the safe recesses of the expanded bulb or take a header down the neck of the tube, this is not really the case; for the wise little parent birds in the process of weaving it have constructed a kind of partition just where the neck is united to the bulb, in such a manner as effectually to prevent such a disaster befalling their offspring.

* *Birds of India*, Vol. II.

CHAPTER XIII.

MAMMAL CRAFTSMEN.

AMONG the Mammals we shall seek in vain for that highly skilled craftsmanship which is such a characteristic feature of Bird and Insect life—that is, of course, excluding Man from our survey. The great man-like apes are said to build temporary nests or arbours among the branches of the trees, but the statements regarding their appearance and construction are very conflicting and meagre, and at best seem chiefly founded on statements made by natives, always an unreliable source from which to obtain accurate information. The larger Carnivora have their lairs or hiding-places, generally caverns, holes in the ground, or similar situations adapted to their requirements, as places of shelter and retreat, or as nurseries for their young. Of the more remarkable burrows I have already given one or two examples in Chapter X., but there are other Mammal craftsmen whose skill I would briefly refer to here, and who are not only burrowers in the soil, but often more or less expert nest-builders.

The graceful, lively little Squirrel of our woodlands is quite a skilled architect, building a good-sized dome-shaped nest either in the fork of a bough high



THE NEST OF THE WEAVER BIRD.

One of the most remarkable examples of the art of basket-weaving.

Mammal Craftsmen.

up among the branches or in a hole in a tree. The material used in its construction consists of slender twigs, fibres of bark, the slender stems of the honeysuckle, and dry leaves, all carefully interwoven. The top of the nest is dense and thick so as to keep out the rain, while inside the nest has a warm, snug bedding of dry moss and leaves. Lithe and graceful in his movements, leaping from bough to bough with the most astonishing ease and lightness, our little brown friend of the woodland glade presents a most charming picture; and it is a pity that in the eyes of the forester he is rather a bad character, for he is said to do considerable damage in young plantations, by ring-barking sapling trees, as well as destroying quantities of buds. He is also given to bird-nesting, I am sorry to say, and destroys both eggs and recently hatched nestlings. If taken quite young—that is practically from the nest—the Squirrel becomes a charming and amusing pet; though personally I dislike the idea of caging such an essentially woodland freedom-loving creature.

Old Squirrels are practically untamable, and it is a sad sight to see them beating at the bars till their noses are all seared and bloody in their vain endeavour to escape. Such an unfortunate I befriended some years ago, my attention having been drawn to him by his restless movements in a rusty old cage hanging outside a shop near St. Martin's Lane, at that time one of London's great centres for shops providing pet animals and birds. After some higgling I purchased the poor beast and brought him home, where he was given a nice clean cage with a roomy nest-box and

How Animals Work.

plenty of food and water, for a Squirrel loves a drink of clear water. In the quietude of my study he became less frantic in his efforts to escape, but if any one approached the cage suddenly he would dash about and reopen the wound on his nose. However, his confinement was not to last long, for the following week I went down to stay for a while in the New Forest, and took Master Squirrel with me. Needless to say, the noise and bustle of the train journey nearly drove him frantic, and I thought it best to give him a couple of days' rest to recover his nerve ere setting him free; and these two days were devoted on my part to the careful selection of a suitable and remote spot for his liberation, for I knew if he was let out in a wood already the home of several Squirrels, he would probably be at once attacked as an interloper. A pleasant belt of woodland, with beech, fir, and oak trees, and a little tinkling stream running through it, was selected, and on the third morning we set forth with the cage wrapped up in a cloth, and Master Squirrel pounding about excitedly inside. Although nearly ten long years have passed away since that bright July morning, the scene comes back to me as vividly as if it were but yesterday—the sweet hot smell of the heather as we crossed a stretch of bogland, the fragrance of honeysuckle on the edge of the wood, and then the quiet peace within, broken only by the gentle murmur of the soft summer breeze among the branches and the half-sleepy cooing of a pair of wood pigeons. Arrived safely, the cage was set down and the cloth removed. The Squirrel at first wildly dashed about, startled by his journey and the removal of the cloth; then with little hands pressed

Mammal Craftsmen.

against the bars of his prison he began to peer eagerly out at the woodland, looking all round, and at last, giving vent to the most plaintive cry imaginable, darted into his nesting-box as if the sight of his natural surroundings and the knowledge that he was a helpless prisoner in their midst were more than his little heart could stand. Very gently I opened wide the door of his cage, and then drew back out of sight behind a convenient bush, that I might watch without disturbing the little creature. Once more he issued from the nesting-box to explore the bars of his cage in the vain hope of finding a way of escape. At last he came to the open door, rested his forefeet on the ledge and looked out intently, longingly, and again gave the same plaintive, half-crooning call.

Poor little chap, although standing on the very threshold of liberty, he had not yet realized it. There he sat for fully three minutes, his ears pricked and poor battered nose gently working, sniffing the scents of the forest; then he stretched his head forward, and found no bars in front, or to right or left, or above, and in a moment he realized his freedom. A little flash of ruddy brown fur darted from the cage swift and straight for the nearest tree, up which he sped with lightning-like rapidity. I think both I and my dear wife, who had come with me to witness the return to freedom of our little friend, had rather tight throats and an unaccountable mistiness of vision for a few minutes as we softly stole out of the woodland into the bogland path; but we were a very happy couple all that glorious long summer day, for we had been able to give back the joy of life and freedom to one of

How Animals Work.

Nature's children. During our stay we twice caught sight of our Squirrel amongst the branches of the wood—there was no mistaking the scar upon the bridge of his nose, which could be plainly seen through our field glass; and thrice in the following year I saw him, only just a furrow across his nose, showing where the old scar had been. So I hope that in the end he “married and lived happy ever after,” as the story books of our childhood had it.

The Dormouse, most compact and delightful little creature, is also a nest-builder. It places its nest either in a hollow in the ground, low down amidst the branches of bushes, or now and then in the hollow of a tree stump. Moss, grass, dry leaves, small twigs, and pine-needles are the materials used, the Dormouse matting them together into a neat little globular nest, snug and warm, within which, coiled up into a ball, it sleeps away the greater part of the long cold winter months, only rousing up on particularly mild days to eat some of the little store of food which it had carefully provided and stowed away in the autumn for winter use. Probably on account of its more sedentary habits, although it is lively enough in all conscience during the height of summer, the Dormouse takes much more kindly to confinement than the Squirrel ever does, and soon becomes a wonderfully tame and confiding little pet, becoming very lively at night. In its natural state, during the summer months, it is as lively as a cricket in the evening, but sleeps peacefully in its nest most of the day. It climbs with wonderful adroitness among the small twigs and branches of shrubs and small trees, often hanging by its hind feet from

Mammal Craftsmen.

a twig to reach a fruit or nut which is otherwise inaccessible.

The tiny Harvest Mouse is a wonderfully expert little architect, and provides for its offspring one of the daintiest cradles formed by any Mammal. The globular nest is placed, according to the locality, upon several grass leaves split and interwoven with the other materials, or suspended at a height of from eighteen inches to three feet above the ground, upon the twigs of some shrub, or between the stalks of tall, strong grasses or corn. It is composed externally of slit leaves of the reeds or grasses among which it is found, the little mouse, with the aid of its sharp teeth, carefully dividing each leaf longitudinally into six or eight threads, which are then all woven together so as to produce a wonderfully firm, compact structure. Within, the nest is stuffed with all sorts of soft plant substances so closely that one wonders how mother mouse can find room for housing her youngsters. The completed nest, about the size of a cricket ball, is really a wonderful piece of work.

The Musquash, although essentially a burrower, under certain conditions will construct what is called a hut to live in. The animal is a native of North America, being most numerous in Canada and Alaska, where it frequents the rivers, lakes, and ponds. In some respects its habits somewhat resemble those of the beaver, and for this reason it was called the beaver's little brother by the Indians; while another popular name, that of the Musk Rat, it gains from the musk odour diffused by the secretions of a large gland. The animal generally lives in a burrow which it digs in the

How Animals Work.

bank of the stream or lake it happens to frequent, consisting of a chamber with numerous passages, all of which open beneath the surface of the water. Under certain conditions, however, the Musquash departs from this rule, and builds for itself a house of a dome-like shape, composed of sedges and grasses and similar materials all plastered together with mud, and supported upon a mud embankment sufficiently high to raise it well above the water. This house has a single chamber some sixteen inches to two feet in diameter, and is entered by a passage which opens beneath the water. Other passages leading out of this first excavated gallery are sometimes present, all lead downwards and have their openings below the water, and are said to be made by the animal in its search for the roots of various aquatic plants upon which it feeds. Within this house the Musquash passes the winter, its living room being furnished with a soft bed of leaves and sedges.

The Beaver was once to be found generally distributed all over the forest regions of the northern parts of the Northern Hemisphere; it ranged over the whole of Europe, and was an inhabitant of the British Isles down to about the beginning of the eleventh century. (Beverstone in Gloucester and Beverley in Yorkshire are two place names that had their origin in the presence of the Beaver, just as Brockley and Brockenhurst tell of the Broc or Badger.) Now, however, the European Beaver is nearly extinct; and a similar fate presses hard upon its American brother, so mercilessly and unceasingly has it been hunted down and slaughtered for its beautiful coat. The

Mammal Craftsmen.

favourite haunt of the Beaver is the banks of some small stream which has its course through well-wooded country, especially where the trees are chiefly willows, birches, and poplars, upon the bark of which it feeds:

Although in populous countries the Beaver is content to use a long burrow for his home, in the wild and lonely regions far from the haunt of his cruel foe Man he builds a most elaborate house or lodge wherein to dwell. This lodge is a dome-shaped structure, composed of sticks, grass, and moss, all woven together and plastered with mud, increasing in size and in the thickness of its walls year by year as fresh material is added for repairs. Within this dome-shaped house is a central chamber with its floor a little above the level of the water, and with two shafts which have their outer aperture beneath the water. One of these shafts is driven at a straight and moderate incline, and it is up this that the Beavers drag the pieces of wood and bark that are to be stored within the lodge to form part at least of the winter food supply ; the other shaft is more abrupt in its descent, often winding in its course, and is said to be the usual means of entrance and exit. Both these passages vary a good deal in length in different lodges, often being many feet in length, but they are always very neatly constructed and finished off. The central chamber varies, of course, in size, but the larger ones generally measure about seven or eight feet in diameter and two or three feet in height ; while the floor is snugly carpeted with grass, bark, and wood chips.

In some lodges, in addition to this large living room, and opening out of it, are special storerooms

How Animals Work.

which at the approach of autumn are well filled with a supply of winter fodder. Outside, the whole fabric measures from twelve to twenty feet in diameter and some six or eight feet in height. In front of the lodge, according to Audubon, the Beavers scratch away the mud of the bottom of the stream until they make the water of sufficient depth to enable them to float their pieces of timber to this point, even when the water is frozen ; and communicating with this a ditch surrounds the lodge, which is also made so deep that it will not readily freeze to the bottom. It is into this ditch or moat, and the deep water in front of the lodge, that the passages from the living chamber always open, and thus the Beavers can at any time make their way out unobserved.

For the building of the lodge, and for food, the Beavers cut down the trees on the edge of the stream by the aid of their strong chisel-like teeth. This is accomplished by gnawing all round the trunk for a certain distance, and gradually working deeper and deeper into the substance of the tree in such a manner that just before its fall the tree stands upon quite a slender waist of wood, with the trunk both above and below this tapered off into the form of two cones whose points are united by the waist. The Beavers work in such a way as to weaken the side nearest to the water, so that when the tree falls it descends in that direction. The tree felled, its trunk and branches are cut up into lengths of from five to six feet, which, after the bark has been stripped off and eaten, are employed in the construction of the lodge, or the formation of the dam which may be thrown across the stream to keep the

Mammal Craftsmen.

water at a given level. These dams are really very remarkable structures, often of great length, not infrequently upwards of one hundred and fifty yards. They run out across the stream from bank to bank, either in a straight line or curved in a bow, according to the character of the stream and the requirements of the Beavers. Like the lodges, they are composed of lengths of timber cut from the trunks and branches of the trees, filled in with smaller sticks, roots, grasses, and moss, and all plastered with mud and clay in the most workman-like manner, until the whole structure is made perfectly water-tight. By means of these dams the Beavers are able to convert even small rivulets into large pools of water, often many acres in extent, and dotted about with islands upon which the lodges are constructed. Thus, all unconsciously, the Beavers exercise a considerable influence upon the general aspect of the locality inhabited by them, which may persist long after they themselves have disappeared from those regions. By their constant felling of the trees they gradually produce clearings in the forest often many acres in extent, and the lagoon produced by damming back the water becomes converted into a peat-moss. These peaty Beaver-meadows, as they are called, are still to be traced in many countries where the Beaver no longer exists.

CHAPTER XIV.

WORKERS IN PLANT TISSUES.

THERE are a large number of insects who are more or less expert workers in plant tissues, using these as shelters either for themselves or for their offspring. As we have already seen, many Wasps work up fragments of woody tissues into the most beautiful papery material with which to build their nests, while the Carpenter Bee excavates galleries in the stems and branches of trees and shrubs, and forms therein a series of partitioned chambers, snug, well-provisioned nurseries for the safe rearing of its offspring. It is to some distant relations of these hymenopterous insects that I would now draw your attention—to those small insects which are only known to most people by the results of their labours, for the majority are small enough to escape attention—namely, the Gall-flies, scientifically known as the *Cynipidæ*.

The Gall-flies are responsible for those many shaped and often brightly coloured swellings on leaves and twigs of various trees and plants called galls. The insects are small, frequently minute in size, and usually black or blackish brown in colour. The true nature and origin of the excrescences caused by these flies was a great puzzle to the ancients, and indeed, although

Workers in Plant Tissues.

our knowledge has been considerably advanced, thanks to the direct observations and experiments of modern naturalists, there are many points which still remain obscure. Up to two hundred years ago it was generally believed that these galls were entirely vegetable productions, and that the maggots found in them were due to spontaneous generation: for it was an article of universal belief throughout the Middle Ages that all maggots in general arose from the various organic substances in which they were found, by means of that hypothetical process called spontaneous generation. The great anatomist Malpighi, however, aware of the unsatisfactory nature of such a belief, began closely to observe these galls, and his studies were soon rewarded by indisputable evidence of their origin being caused by the work of insects—in fact, they arose from punctures made in the tissues of the plant by the Gall-fly in the process of depositing her eggs. But we must not hastily jump to the conclusion that every gall has been formed through the agency of a Gall-fly, for there are a great variety of insects, as well as mites, which form galls upon many plants, and such galls are often utilized by certain species of Gall-flies, which, cuckoo-like, deposit their eggs in nests provided by other insects. Some of the Scale insects of Australia, for instance, form extremely curious galls on the eucalyptus trees, which are almost invariably inhabited by the offspring of these parasitic Gall-flies. To find out the exact manner in which many of these plant galls originate, therefore, is by no means easy. Those found on the oak, and the handsome mossy-looking bedeguar galls on the wild and cultivated roses, have

How Animals Work.

received a great deal of attention, and the Gall-flies which produce them have been studied and described. Each species of Gall-fly generally appears to have its own particular plant to which it always repairs when on egg-laying intent ; indeed, it is frequently found to confine its attentions solely to one part of the plant or tree, as the case may be ; and where a plant is frequented



Rose Gall.

by more than one species, it will be found that one of the Gall-flies deposits its eggs only in the leaf tissues, another only in the tissue of the stalks, and a third, perhaps, on the main stem or roots.

One of the best known of our British galls, the large and often beautifully coloured one to be found on both wild and cultivated rose bushes in almost any part of the country, is produced by the little Rose Gall-fly,

known to science by the name of *Rhodites rosæ*. Although this gall looks just as if it arose from part of the stem or twig of the rose bush, it is really a leaf gall, and the manner of its production is rather remarkable. The little female Rose Gall-fly in the spring of the year may often be seen by those who know her busily engaged in hunting over the rose bushes seeking a suitable spot for depositing her eggs.

Workers in Plant Tissues.

The position she always finally selects is a bud, not a flower-bud, but one that should under ordinary conditions produce a twig and leaves. This bud she proceeds to prick with her sharp-pointed ovipositor in three places, in the most systematic manner. The three spots in the bud selected for piercing by the Gall-fly are just the three points where the rudiments of leaves exist, and these, instead of developing into leaves, by their changed mode of growth give rise to the bedeguar or gall. Usually this gall is of large size, handsome in colour, and if cut open will be found to contain numerous cells, each the nursery of a tiny larva ; but imperfect specimens are by no means uncommon, such as a small one seated on a full-grown rose leaf, and these, it is thought, are due to the failure on the part of the parent insect to complete the pricking operation. These rose galls often contain, in addition to the rightful inhabitant, other larvæ that have emerged from eggs placed in the tissue of the perfect gall by one or other of the parasitic Gall-flies.

The oak is a particular favourite with the Gall-flies, and produces in consequence a number of different shaped galls. On the under surface of the leaves are to be found quantities of the so-called spangle galls—oval, flat bodies that in size and shape resemble the metallic discs called spangles ; the oak apple is another form familiar to most people ; and a third type, called currant galls, are equally well known. Experiments carried out with a view to finding out the particulars of the life history of some of these oak-frequenting Gall-flies have brought to light many interesting points, and proved beyond doubt that

How Animals Work.

in some species a regular alternation of generations exists. Thus, in Vienna, galls on the oak leaves produce about the end of April a Gall-fly called *Chilaspis lowii*, both male and female insects emerging from the galls. The fertile females later lay eggs on the ribs of the leaves of the same kind of oak, but their work produces a different kind of gall from that in which they were born. These galls, along with the leaves, fall from the trees in the autumn, and in July or August of the following year a Gall-fly emerges from them. It is quite a different creature in appearance



Oak Gall.

from the mother, however—so different, indeed, that before its life history was known it was thought to be a totally different insect, and had received the name of *Chilaspis nitida*. Only females of this form are known to develop, no male having ever been seen; and these female Gall-flies, without any intercourse with a

male, lay their eggs in the young buds of the oak that are already present in the autumn, and in the following spring, when the buds begin to open and leaves to develop, those that have had an egg laid in them produce a gall from which true *Chilaspis lowii* Gall-flies of both sexes emerge in April and May. The complete cycle of the two generations therefore extends over two years, and the generation that occupies the longest time for its production consists only of females. In some species in which this alternation of generation is known to exist, a series of generations com-

Workers in Plant Tissues.

posed entirely of females, all similar to one another, are produced.

From the above necessarily brief outline it will be seen that these tiny Gall-flies, which by means of their minute ovipositors are able to pierce the tissues of the plants, deposit their eggs beneath the tissues, and cause those changes which produce such strange and often beautiful growths, have a most singular and interesting life history.

There are a large number of Caterpillars which, from their habit of making their homes in leaves which they curl up in various ways, are popularly called Leaf-rollers. They are quite expert little craftsmen in their own humble fashion, some using a single leaf, others employing two or more in the construction of their nest, and all display a wonderful variety in their manner of accomplishing the task. Some we find bend the leaf longitudinally, and are content just to fasten the two edges together; while others bend it transversely, fixing the point of the leaf to the middle vein. Some roll up the leaf longitudinally, so as to produce a hollow cylinder of the same length as that of the entire leaf; others roll it transversely, or cut a slit and roll up only a small portion of the leaf. All these Caterpillars are very small, and it is really not by their own strength, but by their mechanical skill, that they are able to roll up the leaves to form their homes.

Take, for instance, the little Caterpillar which in some seasons causes considerable damage to the foliage of the lilac bushes, and which is only about three-sixteenths of an inch long. Selecting a point where

How Animals Work.

the edge of the leaf has a slight curvation, the tiny Caterpillar attaches to it a thread formed by the silk glands in his mouth, and bending his head and the front part of his body as far as he can reach in the opposite direction—that is, towards the centre of the leaf—fixes the other end of his thread to that spot. Backwards and forwards, from point to point, he swings, weaving a whole series of strands, so that a little cable is at last formed which is attached at one end to the slightly incurved edge of the leaf, and at the other to a spot on the blade of the leaf. The cable is fairly taut, but it has not drawn the edge of the leaf inwards, for the very obvious reason that the little Caterpillar has not sufficient physical force to haul in the cable hand over hand. But now the wee insect changes his position and spinning work, and at once shows himself a skilled mechanic, for what he cannot accomplish by mere “brute strength” he proceeds to accomplish by mechanical means. It is obvious that any pressure exerted on the taut cable would shorten its length, and drag the curving edge of the leaf inwards; and this is precisely what the Caterpillar proceeds to do, not by placing weights on the cable, but in a much stronger and more effective manner, by weaving a series of threads across the cable and at right angles to it, pressing the end of the cable down with the weight of his body as he swings his head backwards and forwards in weaving and fastening down the transverse strands. Having fixed his last cable in this way, the little Caterpillar proceeds to attach another to the margin of the leaf at a short distance from it, repeating the same process again and again, until

Workers in Plant Tissues.

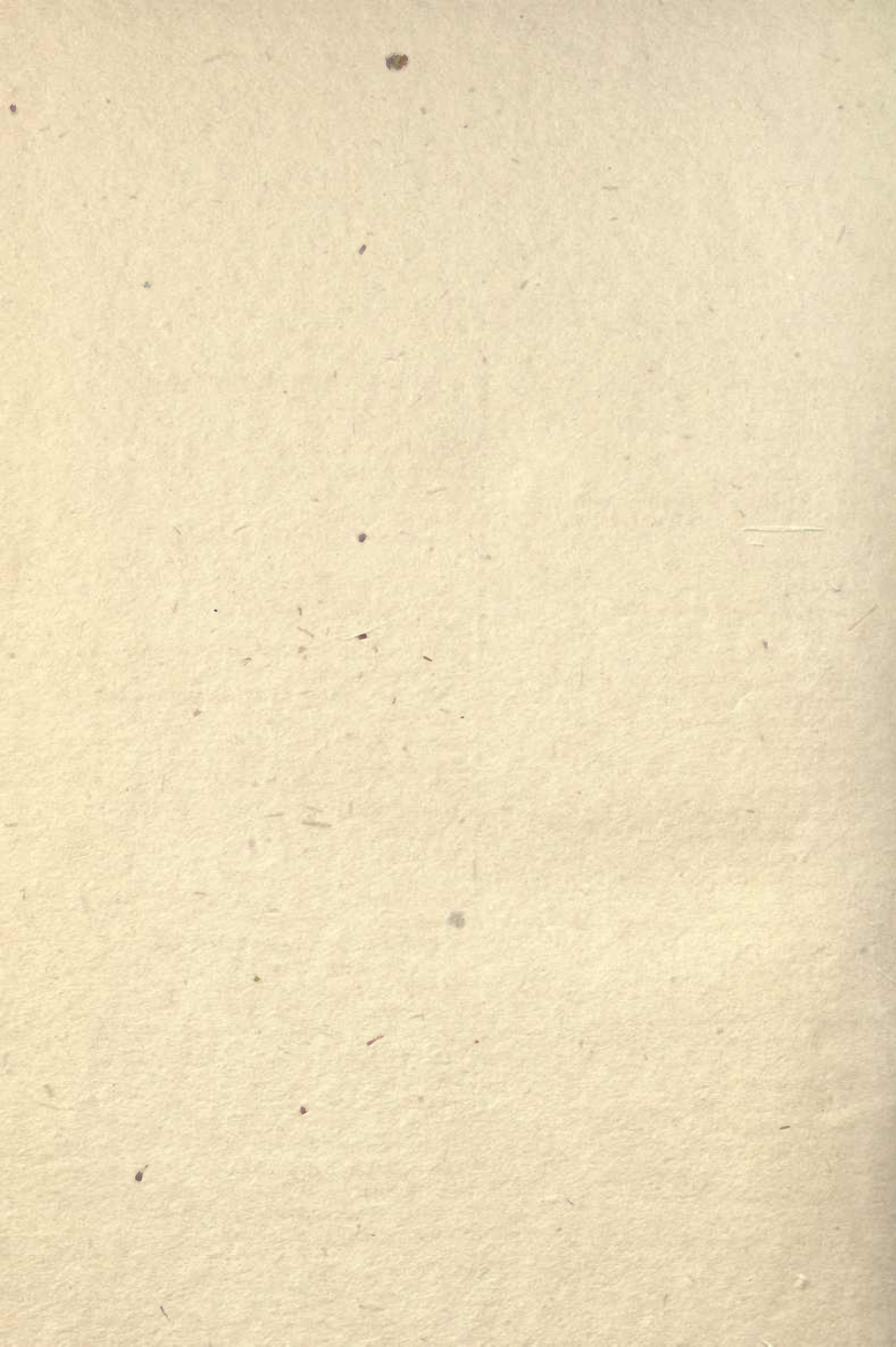
a definite curl to the leaf is obtained. Then the whole process is started all over again, this time, of course, one end of the cable being attached to the crest or top of the curve; and so, slowly but surely, the little insect mechanic accomplishes his task, and rolls up his leaf. Once these labours are completed, he disappears from view into the very heart of his rolled-up leaf, there to feast in safety upon its soft tissues. Broadly speaking, this is the method employed by all the leaf-rollers, but, as already stated, the direction of the roll varies considerably.

The little Poplar Leaf Weevil is also an expert leaf-roller, but as she has no silk wherewith to hold the curves in position, the task for her is a difficult and laborious one. Having selected a leaf, the little Beetle, with the aid of her curious snout, makes a tiny hole in the stalk, not deep enough to sever it, but sufficient to cause an injury which will upset the regular flow of the sap fluids, and so cause the leaf to wilt. It soon begins to droop under its own weight, until it hangs straight down from the point where the Weevil made the puncture, and is soon sufficiently limp and plastic for her purpose. Then she takes up her stand on the upper surface of the lance-shaped leaf, not at its tip, but at the edge of the middle of the blade, and with the aid of her small but strong claws she begins to drag the edge of the leaf inwards. It is a most laborious task for the little insect, and not for a moment dare she relinquish her hold upon the incurving leaf, lest it spring back and cause her to begin her labours all over again. Therefore she does not work with great speed, but slowly, precisely, doggedly. Backwards

How Animals Work.

and forwards she travels, bending and shaping the incurving leaf until it is rolled up into a perfectly neat cylinder, the edges of which are secured by a sticky cement exuded by little glands which are present along the edge of the leaf. All this labour has been undertaken by the little Weevil not for her own benefit, but to form a safe nursery for her offspring. Within the folds of each rolled-up leaf she has deposited from one to four eggs, from which in due course will emerge the little larvæ, who, thus safely hidden from view, will feed upon the soft tissues of their leafy cradle.

INDEX.



INDEX.

AMMOPHILA, 94.
 Ant-lion, the, 163.
 Ants, 100-121.
 —, Eciton, or Foraging, 111.
 —, Mason, 103.
 —, Satiba, or "Parasol," 109.
 —, White or Termite, 115-121.
 —, Wood, 100.
 Apes, arbours of, 240.
 Atolls, 22.
 Australian birds' nests, 210.

BADGER, the, 171.
 Basket Argiope, 134.
 — Worms, 160.
 Beavers, 246-249.
 Bees, Carder, 87.
 —, Carpenter, 86, 250.
 —, Hive, 74.
 —, Leaf-cutting, 84.
 —, Mason, 79-84.
 —, Poppy, 86.
 Bird architects, 189.
 — —, foreign, 210.
 —, diggers and burrowers, 184.
 Bobolink, nest of, 235.
 Brain corals, 21.
 Brick-maker Rotifer, 51.
 Bullfinch's nest, 191, 195.
 Burrowing Owl, 177.

CADDIS-WORMS, 54.
 Calling Crabs, 182.
 Cameos, 36.
 Carder Bee, 87.
 Carpenter Bee, 86, 250.
Caryophyllia Smithii, 18.
 Cassique, nest of, 235.
 Cataract Bird, nest of, 213.

Caterpillars, cocoons of, 153 *et seq.*
 —, Leaf-rolling, 255.
 Caudata, 152.
 Chaffinch, nest of, 196.
 Chiff-chaff, nest of, 201.
 Clams, 30.
 Clam shells, giant, 37.
 Clothes Moth, caterpillars of, 162.
 Cockles, 39.
 Cocoons of caterpillars, 153.
 — of spiders, 149-153.
 Conch shells, 36.
 Corals, reef-building, 17, 19, 21 *et seq.*
 —, solitary, 18, 20.
 Coral reefs, origin of substratum, 24 *et seq.*
 Courtilière, 166.
 Cowrie shells, tropical, 34.
 Crab tribe, as diggers, 179.
 Crabs, Calling, 182.
 Crow, nest of, 195, 205.
 Cup Coral, 18, 19.

DATE-SHELL, 42.
 Devonshire Coral, 18-20.
 Dicæum Swallow, nest of, 213, 214.
 Digging insects, 163 *et seq.*
 Dormouse, 244.
 Duck-billed Platypus, 183.

EAR-SHELL, 34.
 Eciton Ants, 111.
 Eumenes, 93.

"FAIRY-LAMP" Spider, 150.
 Fairy Martin, nest of, 210.
 Fan Sabella, 45.
 Fantail, White-shafted, nest of, 221.
 — Warbler, nest of, 229.

Index.

Fishes, nest-building, 56-64.
Foraging Ants, 111.
Foraminifera, 9, 10 *et seq.*
Fur Moth, caterpillar of, 162.

GALL-FLIES, 250.
Garden Spider, 129, 133.
Giant Clam, 37.
Globigerina, 13.
Gold Crest, 198.
—— —, nest of, 200.
"Golden-head" Worm, 49.
Goldfinch, nest of, 196.
Gopher, the, 172.
Gossamer Spiders, 124.
Grallina, Pied, nest of, 219.
Gymnarchus, 60.

HAMSTER, 178.
Hang-nests, nests of, 234.
Harvest Mouse, 245.
Hawfinch, nest of, 195.
Helmet shell, 36.
Heron's nest, 195, 207.
Heterotis, 60.
Hive Bees, 74.
Honey-eaters, nests of, 212.
Hornbill, nest of, 226.
House-flies, dangers from, 65.
House Martin's nest, 207.
Humming Birds, nests of, 232-233.
Hunting Spiders, 153.

INSECT builders, social, 65-78.
—— —, solitary, 79-99.
Insects as workers on plant tissues, 250.
Island builders, 17-26.

KINGFISHER, 185.

LACKEY MOTH cocoons, 153.
Ladder-shells, 33.
Leaf-cutting Bees, 84.
Leaf-rolling Caterpillars, 255.
Lima, 28, 38.

MAGPIE, nest of, 203, 206.
Magpie-lark, nest of, 219.
Mallee Bird, nest of, 215.
Mammals, craftsmanship of, 240-249.

Marmot, Alpine, 177.
——, Prairie, 175.
Martin, Fairy, 210.
——, House, nest of, 207, 208.
——, Sand, nest of, 184.
Mason Ants, 103.
—— Bees, 79-84.
—— Spiders, 150.
Meadow Pipits, nest of, 196.
Megapode, nest of, 216.
Melicerta, 51-53.
Microscopic builders, 9-16.
Mining insects, 163 *et seq.*
Mole, Common, 168-171.
Mole Cricket, 166.
Mollusca, 28.
Moths, cocoons of, 153 *et seq.*
Mound Bird, nest of, 215-216.
Mouse, Harvest, 245.
Mullein Moth, cocoon of, 159.
Mushroom corals, 20.
Musk Rat, 245.
Musquash, 245.

NAUTILUS, the, 10, 11.
Nest architecture of birds, 189.
—— —, digging, burrowing, and carpentry, 184.
Nest-building fishes, 56-64.
Nummulitic limestone, 15.
Nuthatches, British, nest of, 224.
——, Syrian, nest of, 224.

OAK-GALLS, 253.
Odynerus, 98.
Oriole, Baltimore, nest of, 234.
——, Crested, 235.
——, Orchard, nest of, 235.
Ormer, 34.
Ornithorhynchus, 183.
Oven Bird, 221-224.
Owl, Coquimbo, 177.

PARADISE-FISH, 60-62.
Parasol Ants, 108.
Pasteboard Wasps, 74.
"Pelican's Foot" shell, 33.
Pelopæus, 90.
Pholas, 41.
Piddock, 41.

Index.

Pied Grallina, nest of, 219.
 Plant tissues, workers in, 250-258.
 Platypus Duck-billed, 183.
 Pocket-gopher, 172.
Polistes Gallica, 72.
Polybia Uliacea, 73.
 Pond life, 50.
 Poplar Leaf Weevil, 257.
 Poppy Bees, 86.
 Pouched Rat, 172.
 Prairie Marmot, 175.
 Processionary Moth, caterpillars of, 153.
 Puffin, 186.

RADIOLARIA, 16.
 Rain-bird, 186.
 Rainbow-fish, 62-64.
 Rattlesnake, 177.
 Razor-shell, 40.
 Redpole, Lesser, nest of, 199.
 Reed Warbler, nest of, 199.
 Reef-building Corals, 17-26.
 Reparium, 152.
 Ring Dove, nest of, 203.
 Rock Dove, nest of, 204.
 — Warbler, nest of, 213.
 Rook's nest, 206.
 Rose Gall-fly, 252.
 Rotifers, 51.

SAND MARTIN, 184.
 Sand-mason Worm, 47.
 Saüba Ants, 109.
 Saxicava, 42.
 Scale insects, 251.
 Scallop-shells, 30, 31.
 Screw-shells, 32.
 Sea-adder, 59.
 Sea-butterfly, 38.
 Sericornis, Yellow-throated, 211.
 Serpula, 43.
 Shell-builders, 27-42.
 —, bivalve, 32, 37.
 —, univalve, 32.
 Shell-structure, 29.
 — of Foraminifera, 11.
 Sheet-weaving Spiders, 139.
 Silkworms, 154.
 Snap-net Spider, 137.

Social insect builders, 65-78.
 Solen, the, 40.
 Solitary builders, 79.
 Spiders, 123 *et seq.*
 —, Banded, 151.
 —, Basket Argiope, 134.
 —, Cocoons, 149-153.
 —, Gossamer, 124.
 —, Mason or "Fairy-lamp," 150.
 —, Orb-weaving, 129, 135.
 —, Reparium, 152.
 —, Sheet-weaving, 139.
 —, Tailed, 152.
 —, Tarantula, 141.
 —, Trap-door, 142-149.
 —, Triangle or Snap-net, 137.
 —, Water, 139.
 —, webs, 128.
 —, Wolf, or Hunting, 153.
 Spinners and weavers, 122-162.
 Spondylus, 37.
 Squirrel, nest of, 241.
 Sticklebacks, 56-60.
 —, Marine, 59.
 Stock Dove, nest of, 204.
 Stonechat, nest of, 195.
 Swallow, Dicaeum, 213, 214.
 Swallow's nest, 207.
 Sycamore Moths, cocoons of, 158.

TAILOR BIRD, nest of, 230.
 Tarantula, 141.
 Termites, 115-121.
 Thorny Oyster shell, 37.
 Thrush, Song, nest of, 192, 195.
 Tiger Beetle larvæ, 165.
 Tiger Moth, cocoon of, 159.
 Tit, Long-tailed, nest of, 197.
 Titlark, nest of, 196.
 "Top-shells," 33.
 Trap-door Spiders, 142-149.
 Triangle Spider, 137.
 Trochus, 33.
 Tube-builders, 43-55.
 Turtle Dove, nest of, 203.

WARBLER, Fantail, nest of, 229.
 Wasp, Armadillo, 72.
 Wasp, Common, 65-70.
 —, Pasteboard, 74.

Index.

- Wasp, *Polistes Gallica*, 72.
——, *Polybia*, 73.
——, Solitary, 79, 89 *et seq.*
——, Wood or Bush, 70-72.
Water Spider, 139.
Weaver Birds, nests of, 234, 235-239.
Weavers and spinners, 122-162.
Weevil, Poplar Leaf, 257.
Wentletraps, 33.
White Ants, 115-121.
Willow Wren, nest of, 201.
Wolf Spiders, 153.
Wood Ants, 100.
Wood Pigeon, nest of, 203.
—— Wasp, 70-72.
Woodpecker, Green, 186.
——, Great Spotted, 188.
——, Lesser Spotted, 188.
Wool Moth, caterpillars of, 162.
Worms, Marine tube-building, 43 *et seq.*
—— ———, Varied-footed, 48.
Wren, nest of, 202.
YAFFLE, 186.
Yellow-throated Sericornis, 211.

THE END.

